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ABSTRACT

This curriculum guide outlines three credits of study, one credit for each of the grade levels 10, 11, and 12. Intended as an optional study area, the program provides awareness and exploration for those students who aspire to postsecondary study and introduces skills to those who wish to explore trades and technologies in employment after school. Each level has core and option modules that offer flexibility. Introductory materials include an overview, information on implementation, and goals and objectives. Electricity/Electronics (E/E) 101 has 11 modules: student orientation and safety, tools and soldering techniques, direct current theory, passive components, alternating current theory, active components, power supplies, audio circuits, residential wiring, career exploration, and printed circuits. E/E 201 has nine modules: student orientation and safety, components, amplifiers, electronic circuits, radio, optoelectronics, residential wiring, printed circuits, and career exploration. E/E 301 has 10 modules: student orientation and safety, components, electronic circuits, electronic communication system, television, digital concepts and microcomputers, fibre optics, robotics/interfacing, residential wiring, and career exploration. Each module has these components: major objective, suggested materials. Appended are a nine-page chart correlating student texts and teacher references to module topics, seven pages of references, and a list of 15 publishers. (YLB)

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Manitoba
Education

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101, 201, 301

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This guide replaces the Industrial Arts 10-12 Electronics guide of 1965. It has been developed as part of the revision for Industrial Arts curricula for grades 7 through 12 programs in Manitoba schools. This guide has been based upon recommendations provided by the Industrial Arts 10-12 Steering Committee, and prepared as a result of recommendations to proceed with this project by the Curriculum Policy Review Council.

The Electricity/Electronics 101, 201, 301 Industrial Arts Senior High Curriculum Ad Hoc Committee provided the writer with the necessary technical and pedagogic support in reviewing the curriculum throughout its development.

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overview

OVERVIEW

INTRODUCTION

The Industrial Arts 10-12 Electricity/Electronics curriculum guide outlines three credits, one credit for each of the grade levels 10, 11, and 12. Several general features have been integrated throughout the guides:

1. Industrial Arts provides learning opportunities for the wide-ability range of learners
2. Career exploration and planning is incorporated into Industrial Arts programs;
3. Industrial Arts at the secondary level assumes that students have had no junior high school exposure to the program area; and
4. Basic and generic skills include problem solving, creative designing and decision making.

This program should be viewed as an optional study area for all secondary students. It provides awareness and exploration for those students who aspire to post-secondary study, as well as introduces skills to those students who wish to explore trades and technologies in employment after school. The avocational use of basic and generic skills serves the entire spectrum of students.

Schools are encouraged to make special efforts to include students of both sexes in Industrial Arts. It is possible for the practical arts to play an important role in reversing sex-role stereotyping.

RATIONALE

Electricity/Electronics 101, 201, 301, with its "hands-on" emphasis, has been designed to provide students with the opportunity to develop generic skills. Specifically, the Electricity/Electronics program offers experiences in the following areas:

- planning
- diagnosing
- assessing and estimating costs
- evaluating
- troubleshooting
- adjusting
- problem solving
- decision making.

Electricity/Electronics 101, 201, 301 allows the student a flexible curriculum through which one can exercise time management, quality control, and teamwork.

This curriculum guide is a statement of INTENT, CONTENT, and DEPTH of study. It is prepared for the teacher as a guideline rather than a mandatory prescription. While teachers are invited to develop their course of study around this curriculum guide, it is left to them to assess and prepare their courses in accordance with their preferences for emphasis, the nature of facilities, their perception of student needs, school and administration philosophies, and community requirements. The use of CORE and OPTION modules is recommended to help the teachers accommodate the variables affecting the program.

STRUCTURE OF THE PROGRAM

Electricity/Electronics 101, 201, 301 assumes that students who enter the program area for the first time will begin study at the 101 level. Each level has CORE modules which must be studied to the extent set by the teacher, and OPTION modules which offer the flexibility described in the Rationale for this course.

ELECTRICITY/ELECTRONICS 101		
MODULE TITLE	CORE-C OPTION-O	PAGE
01 Student Orientation and Safety	C	35 - 37
02 Tools and Soldering Techniques	C	38 - 41
03 D C Theory	C	42 - 57
04 Passive Components	C	58 - 67
05 A C Theory	C	68 - 75
06 Active Components	C	76 - 78
07 Power Supplies	C	79 - 83
08 Audio Circuits	O	84 - 93
09 Residential Wiring	C	94 - 105
10 Career Exploration	C	106 - 107
11 Printed Circuits	C	108 - 109

ELECTRICITY/ELECTRONICS 201		
MODULE TITLE	CORE-C OPTION-O	PAGE
01 Student Orientation and Safety	C	113 - 115
02 Components	C	116 - 133
Minimum - Two of the following three: (C)		
03 Amplifiers	O	134 - 145
04 Electronic Circuits	O	146 - 157
05 Radio	O	158 - 167
Minimum - One of the following three: (C)		
06 OptoElectronics	O	168 - 173
07 Residential Wiring	O	174 - 185
08 Printed Circuits	O	186 - 190
09 Career Explorations	C	191 - 192

ELECTRICITY/ELECTRONICS 301		
MODULE TITLE	CORE-C OPTION-O	PAGE
01 Student Orientation and Safety	C	195 - 197
02 Components	C	198 - 201
03 Electronic Circuits	C	202 - 207
Minimum - Two of the Following Six - (C)		
04 Electronic Communication Systems	O	208 - 214
05 Television	O	215 - 228
06 Digital Concepts & Microprocessors	O	229 - 243
07 Fibre Optics	O	244 - 251
08 Robotics/Interfacing	O	252 - 257
09 Residential Wiring	O	258 - 269
10 Career Explorations	O	270 - 272

implementation

IMPLEMENTATION

SAFETY

Industrial Arts courses, being practical and "hands-on" in nature, require that schools and teachers plan implementation strategies with care to safety concerns. Throughout this guide, special mention is made of safety concerns with regard to higher risk activities. However, SAFETY IS A CONCERN AT ALL TIMES, and it is the responsibility of those who deliver the courses to ensure that adequate and reasonable safety precautions have been taken.

TIME ALLOTMENT

Electricity/Electronics 101, 201, and 301 are considered to be secondary school credits. Each credit is intended to be comprised of 110-120 hours of study. It is left to the schools to adjust their preferred emphases within the course objectives so that unique needs may be met using this guide.

INTEGRATION OF TOPICS

Whereas this curriculum guide provides a suggested sequence of modules and topics within modules, it is recommended that the implementation of the courses be based upon continued integration and revision of the following topics:

- safety
- career exploration
- consumerism
- applied mathematics
- communication skills.

Teachers are expected to integrate topics as suited to their unique preferences, emphases, laboratory requirements, student needs and sequencing of topics within the course.

In some instances it may be the choice of a teacher to provide a THEME around which the course will be implemented. The following themes are commonly integrated in Industrial Arts programs:

1. Process Orientation - a theme which emphasizes the systematic use of materials;
2. Product, or Project Orientation - a theme which focusses on the net result of skills developed;
3. Design Orientation - a theme which develops the creative problem solving, and decision making processes in a generic sense;
4. Tools and Materials Orientation - a theme which focusses on the equipment and supplies used in that particular area of Industrial Arts.

MATERIALS

Suggested text and supplemental materials, both for student use and teacher reference, are referred to throughout the guide. More detailed bibliographic data is provided in an appendix to this guide.

SPECIAL NEEDS STUDENTS

Industrial Arts 101, 201, 301 is designed as an option program for ALL STUDENTS found in the secondary school. Many pupils headed for the technical areas of colleges and universities benefit from secondary exposure to the areas of design, engineering, electronics, and the trades. Industrial Arts serves the special needs of the university student.

The special needs of the greatest number of secondary students would include the exploratory and generic skills development emphasized in Industrial Arts. There is a strong linkage between the practical arts and life-long avocational skills necessary to everyday life.

Industrial Arts can provide some motivational value for students who enroll in these courses because they offer "alternative" credits to other less pragmatic options. The "hands-on" nature of Industrial Arts provides a multifaceted dimension to learning. The many senses involved in practical arts offer students a greater chance to experience success in their particular learning modes. While Industrial Arts is NOT DESIGNED TO BE AN AREA OF STUDY FOR THE LEARNING IMPAIRED, it CAN accommodate students in unique ways.

Many innovative programs for the physically handicapped have been developed with safety precautions being taken into account. The use of jigs and fixtures for specific handicaps has offered new successes to such students. Tailoring Industrial Arts to the handicapped requires careful scrutiny of the hazards, safety requirements, methodologies, and special supports (fixtures, jig aids), as well as the recognition necessary from administrators and colleagues.

EVALUATION

Industrial Arts involves both theoretical and practical learning. Teachers are expected to conduct student evaluations in accordance with: their predetermined course planning (syllabus); the special theme or orientation used in the implementation; the specific objectives set for each student (special needs taken into account); and the standards of performance agreed upon at the outset. These are VALIDITY issues which will reflect the appropriateness of grades issued.

Generally, teachers agree upon this range of criteria. However, each teacher must provide a unique WEIGHTING to validate his/her choice of program variables implemented.

goals and objectives

GOALS AND OBJECTIVES

PROGRAM GOALS

The general goals of the senior high school Industrial Arts programs include the following:

1. to develop creative potential in both vocational and avocational life;
2. to gain an awareness of the role played by technology in the modern world;
3. to assist in the selection of a career choice and career plan;
4. to acquire basic and generic skills in the use of common industrial tools, machines, and processes;
5. to develop a learning environment and attitude that fosters achievement in a practical manner;
6. to discover and develop talents, aptitudes and interests;
7. to develop problem solving skills;
8. to enhance one's understanding of self;
9. to develop teamwork attitudes and skills;
10. to foster an appreciation for decision making and problem solving techniques.

OBJECTIVES

The following listing includes all of the objectives cited in the Level II section of the guide. While the implementation of the objectives is required for both the CORE and OPTION modules, it is left to the individual teachers to assess whether certain objectives will be integrated generally or taught individually. Emphasis and sequencing is also left to the teachers' judgment, based on personal preferences, assessment of student needs and preferences, the nature of facilities, and/or the particular theme around which the course is delivered (process, product, design, or tools orientation).

Electricity/Electronics 101:

1. Student Orientation and Safety

The student should be able to:

- summarize the general outline of the electricity/electronics 101 course;
- recognize the relationship between junior- and senior-high electricity/electronics;
- summarize the method of evaluating students;
- list expectations of behaviour and personal deportment in the lab;
- evaluate hypothetical behaviour in terms of acceptable standards of behaviour;
- outline the layout of the lab;
- identify purposes of tools, machines and equipment;
- understand the importance of safety;
- identify hazards and danger areas;
- recognize the need for appropriate apparel and protective devices in the lab;
- summarize general shop rules and housekeeping practices;
- memorize emergency procedures;
- identify safety features in the lab.

2. Tools and Soldering Techniques

The student should be able to:

- identify the tools commonly used in the field of Electricity/Electronics;
- demonstrate appropriate skill and safety in the use of common handtools;
- identify types of solder;
- list important characteristics of each;
- describe the purpose of flux;
- identify the appropriate tools used for soldering;
- demonstrate correct soldering techniques;
- inspect solder joints;
- remove solder and replace soldered components in an actual circuit;
- understand how to care for soldering tools;
- demonstrate safety in soldering.

3. DC Theory

The student should be able to:

- define atom, proton, electron;
- draw a model of an atom;
- identify the basic parts of an atom, and identify the electrical charge of each;
- define neutral atom and free electron;
- explain the law of electrical charges;
- distinguish between conductors and insulators;
- define current;
- illustrate the difference between conventional current and electron current flow;
- state the units of measurement for electrical current;
- define electromotive force, potential difference, voltage and volt;
- list general sources of electricity and give examples of each;
- distinguish between voltage rise and voltage drop;
- define electrical resistance;
- state the unit of measurement for resistance;
- explain the meaning of resistivity and conductance;
- demonstrate skill in using the ohmmeter to measure resistance;
- demonstrate skill in using various testing devices to measure continuity;
- state Ohm's Law and explain its importance;
- write, using appropriate letter symbols, the three forms of Ohm's Law;
- solve problems using Ohm's Law;
- define power and watt;
- state Watt's Law and explain its importance;
- write, using appropriate letter symbols, the three forms of Watt's Law;
- solve problems using Watt's Law;
- define series circuit, parallel circuit;
- state the effects of connecting batteries and cells in series and parallel;
- state the effects of connecting bulbs in series and in parallel;
- show how voltage is divided in a series circuit;
- describe how current is divided in a parallel circuit;
- calculate total resistance in series, parallel and combination circuits;
- solve problems involving unknown voltage, current, and resistance in series and parallel circuits;
- solve problems involving power and parallel circuits consumed in series;

- identify types of meters;
- describe the uses of different types of meters;
- demonstrate skill in the use of voltmeter, milliammeter, and ohmmeter;
- define magnetic field, flux lines, pole;
- state the basic law of magnetism;
- distinguish between permanent magnets and electromagnets;
- prove that electric current produces a magnetic field around a conductor;
- describe methods of increasing the magnetic field strength surrounding a coil;
- explain how relays and solenoids work;
- give examples of applications of relays and solenoids;
- define inductance, electromagnetic induction, and counter emf;
- state the three things needed for electromagnetic induction;
- explain how self-induced voltages are produced;
- demonstrate motor action and explain the reaction between magnetic fields which causes it;
- describe the operation of a generator;
- list the types of electric motors and outline their applications.

4. Passive Components

The student should be able to:

- identify common components found in electrical circuits;
- draw the appropriate schematic symbol for each of the common components;
- describe the functions of fixed and variable resistors;
- draw the symbols for fixed and variable resistors;
- determine ohmic value of any color coded resistor by using the color bands;
- determine the wattage of any color banded resistor;
- determine the tolerance of any color banded resistor;
- connect resistors in series and in parallel;
- measure ohmic value of resistors using an ohmmeter;
- measure total resistance in series and parallel circuits;
- describe the function of capacitors;
- identify common styles of capacitors;
- draw the symbols for fixed capacitors and variable capacitors;
- describe the construction of common types of capacitors;
- determine capacitance and breakdown voltage of capacitors;
- state factors which affect capacitance;
- connect capacitors in series and in parallel;
- calculate total capacitance in series and in parallel circuits;
- explain the relationship between voltage and current in capacitor circuits;
- test capacitors using an ohmmeter;
- determine tolerances of a capacitor;
- classify switches by their construction;
- identify the symbols and abbreviations for common switches;
- test switches;
- define incandescent and fluorescent;
- explain the construction and operation of fluorescent and incandescent bulbs.

- explain the operation of ionized gas bulbs;
- test incandescent bulbs using an ohmmeter;
- state the common types and sizes of dry-cell batteries;
- compare several common types of cells;
- identify the positive and negative terminals on common cells and batteries;
- test batteries and cells using a voltmeter as a battery checker;
- explain the purposes of fuses and circuit breakers;
- identify common fuse/circuit breaker styles;
- indicate the ampere rating of common fuses/circuit breakers;
- test fuses/circuit breakers using an ohmmeter;
- replace defective fuses/circuit breakers.

5. AC Theory

The student should be able to:

- define alternating current, direct current, sine wave, hertz;
- explain the difference between A.C. and D.C.;
- describe how alternating current flows in a circuit;
- explain the characteristics of a sine wave;
- identify the basic parts of an A.C. generator;
- describe the operation of a simple A.C. generator;
- compare peak voltage, peak-to-peak voltage, and effective (rms) voltage;
- calculate the effective (rms) voltage of a sine wave;
- define inductor;
- state the unit of inductance and the letter which designates inductance;
- explain why a changing current is affected by an inductor, while a steady current is not;
- explain how inductors can develop a counter EMF;
- explain inductive reactance;
- list applications of inductive reactance;
- explain the relationship between frequency of A.C. and inductive reactance;
- explain an example of mutual inductance;
- explain the function and operation of a transformer;
- describe the construction of a transformer;
- explain the relationship among turns ratio, voltage ratio and current ratio;
- solve transformer problems involving turns ratios and power ratings;
- identify transformer losses;
- list applications of transformers;
- define capacitive reactance;
- explain the relationship between AC frequency and capacitive reactance;
- demonstrate that capacitors conduct alternating current but block direct current.

6. Active Components

The student should be able to:

- define semiconductor;
- list common semiconductor devices;
- explain the general function of common semiconductor devices;
- draw and identify the proper schematic symbols for semiconductors devices;
- describe the difference between conventional current and electron current flow;
- identify two basic types of bipolar transistors;

- explain how current flows through junction diodes, LEDs, and transistors;
- use an ohmmeter to test diodes, LEDs, zener diodes, transistors;
- describe suitable replacement procedures for semiconductors;
- demonstrate proper replacement procedures for semiconductors.

7. Power Supplies

The student should be able to:

- identify safety procedures when working with power supplies;
- identify the function of power supplies;
- list power supply applications;
- list the basic parts of a typical transformer-type power supply;
- explain the process of rectification in circuits containing semiconductor diodes;
- identify three types of rectifier circuits;
- draw schematics for and compare the operation of each of the three types of rectifier circuits;
- explain the purpose of filter circuits used in power supplies;
- define ripple;
- draw schematics of common filter circuits;
- describe the effect of filter circuits on the average output voltage of a power supply;
- explain the need for voltage regulation;
- explain the function of a zener voltage regulator circuit;
- identify an IC voltage regulator;
- demonstrate proper connections of an IC voltage regulator in a circuit;
- demonstrate skill in the use of test instruments required for servicing solid state power supplies;
- develop a logical procedure to troubleshoot a defective power supply;
- design a power supply.

8. Audio Circuits

The student should be able to:

- explain what sound is and how it is produced;
- outline the process by which the human body "hears" sound;
- define audio;
- state the range of audio frequencies which can be heard by the average person;
- list several electronic devices which produce or amplify audio frequencies;
- explain the basic process by which sound is converted to electrical energy and back to sound within an audio system;
- draw a simple block diagram of an audio system and explain the basic function of each block;
- select an appropriate audio system for home use;
- define transducer;
- differentiate between crystal and electromagnetic methods of converting sound to electrical energy and vice versa;
- sketch the basic parts of common transducers;
- identify the basic parts of a permanent magnet speaker;
- define frequency response;
- draw the frequency-response curve for the "ideal" speaker;
- classify speakers into three categories according to their frequency response;

- explain what is meant by the impedance and wattage ratings of a speaker;
- demonstrate how to measure the size of a speaker;
- demonstrate how to test a speaker using an ohmmeter;
- explain the function of a speaker crossover network;
- identify the basic parts of light-weight headphones;
- explain why stereo headphones need only three wire connections to the output of an amplifier;
- demonstrate how to test headphones using an ohmmeter;
- explain the difference between a power amplifier and a voltage amplifier;
- give an example of where a power amp might be used and where a voltage amp might be used;
- distinguish between DC and AC amplifier circuits;
- recognize the schematic of a transistor amplifier circuit;
- demonstrate how to inject weak audio signals into an amplifier circuit and produce an amplified output signal;
- identify components commonly found in volume control circuits;
- describe the function of basic volume controls;
- draw a circuit diagram which includes a simple volume control;
- explain the operation of a basic RC tone control;
- draw a circuit diagram which includes a simple RC tone control;
- perform basic troubleshooting operations;
- clean noisy potentiometers;
- locate and rectify problems in cables and connectors.

9. Residential Wiring

The student should be able to:

- explain the electrical power distribution system from generation to residential user;
- identify approximate voltage levels found in each stage of the electrical power distribution system;
- explain the purpose of residential grounding circuits;
- identify ground pins on common electrical cords;
- explain the purpose of double-insulated tools;
- explain the purpose of plug polarization;
- list several safety rules pertaining to residential wiring;
- repair three-conductor and two-conductor appliance cords;
- explain the need for electrical wiring permits;
- explain the need for electrical lock-out devices;
- identify tools and equipment commonly used in residential wiring;
- describe the proper care and use of common tools;
- identify several types of wires and cables commonly used in residential wiring;
- identify several types of insulation used in residential wiring;
- identify the characteristics and applications of several types of insulation materials;
- list some factors which affect the selection of a conductor;
- compare the characteristics of solid and stranded wire;

. explain how electrical wiring information is conveyed to the electrician at the construction or installation site;
. identify common electrical blueprint symbols;
. identify common utility boxes used in house-wiring;
. explain the use and application of common utility boxes;
. explain the use of hangars, covers, and recessed lighting fixtures;
. use Electrical Code listings to determine the proper size and positioning of boxes and related hardware;
. explain the need for a vapor barrier on exterior-surface boxes and enclosure devices;
. identify common electrical devices;
. identify the uses for common electrical devices;
. identify common lighting devices;
. name several common low-voltage devices;
. classify cable, clamp connectors and coupling devices according to use;
. explain the need for anti-short bushings used with armored cable and conduit;
. explain the need for common cable-anchoring systems;
. explain the proper placement of anchoring devices according to the Code;
. use appropriate solderless connectors to splice wires;
. choose appropriately sized solderless connectors for specific applications;
. draw wiring diagrams of common residential wiring circuits;
. construct common residential wiring circuits;
. define small and major appliance circuits;
. identify common small and major appliances.

10. Career Explorations

The student should be able to:

. distinguish between occupations and careers;
. identify a variety of occupations related to the study of electricity/electronics;
. identify skills required for a particular occupation/career;
. outline the training required;
. discuss attitudes for achievement;
. predict the impact of technology on the career/occupation;
. identify major job advertisement sources;
. interpret written job descriptions;
. demonstrate skill in writing resumes and preparing for job interviews.

11. Printed Circuits

The student should be able to:

. locate and identify printed circuit boards in any electronic system which contains one;
. list several advantages of using modern printed circuits instead of hand-wired components;
. discuss the suitablility of PCBs to automated and/or robotic assembly techniques;
. identify at least two materials used as bases for PCBs;
. outline the basic steps used in the construction of PCBs;
. design and produce a PCB;
. demonstrate skill in installing and soldering components into a PCB;
. outline automated industrial techniques for soldering PCBs;

Electricity/Electronics 201:

1. Student Orientation and Safety

The student should be able to:

- . summarize the general outline of the 201 electricity/electronics course;
- . summarize the method of evaluating students;
- . list expectations of behaviour and personal deportment in the lab;
- . evaluate hypothetical behaviour in terms of acceptable standards for this course;
- . outline the layout of the lab;
- . identify purposes of tools, machines and equipment;
- . understand the importance of safety;
- . identify hazards and danger areas;
- . recognize the need for appropriate apparel and protective devices in the lab;
- . summarize general shop rules and housekeeping practices;
- . memorize emergency procedures;
- . identify location of safety features in the lab.

2. Components

The student should be able to:

- . name the commonly used semiconductor materials;
- . describe the characteristics of pure semiconductor materials;
- . explain the bonding structure of semiconductor atoms;
- . describe the process by which pure semiconductors are made into P-type and N-type materials;
- . explain how current flows in intrinsic and doped semiconductors;
- . identify the different methods of diode construction;
- . describe the different methods of diode construction;
- . compare the physical construction and applications of small diodes with those of power diodes;
- . explain diode forward- and reverse-bias characteristics;
- . explain the importance of diode current, temperature and PIV ratings;
- . draw the schematic symbol for the zener diode;
- . describe the forward and reverse current-voltage characteristics of a typical zener diode;
- . describe how the zener diode is used to provide voltage regulation;
- . calculate the maximum safe operating current for any zener diode;
- . design a zener regulator circuit;
- . use a reference manual to look up "specs" on zeners;
- . describe the basic physical construction of bipolar transistors;
- . describe the operation of the bipolar transistors;
- . show how a bipolar transistor should be biased for normal operation;
- . explain the relationship among emitter current, base current, and collector current;
- . explain the concept of transistor "gain" in terms of voltage amplification, and power amplification;
- . test bipolar transistors with an ohmmeter to determine if the devices have internal defects;

- identify the purpose of the junction field effect transistor (JFET);
- describe how a JFET operates;
- properly bias N-Channel and P-Channel JFETs;
- explain the basic difference between the JFET and the MOSFET;
- name the three leads of a FET;
- compare the FET and the bipolar transistor operation;
- compare the construction and operation of enhancement-type and the depletion-type FETs;
- identify the purpose of an SCR;
- name two applications for the SCR;
- draw the standard electrical symbol for the SCR and identify the leads;
- describe the conditions necessary to turn on or turn off an SCR;
- explain the difference between the SCR forward breakover and reverse breakdown voltage;
- test an SCR to determine if it is defective;
- design an SCR circuit;
- explain the operation of the UJT;
- draw the standard symbol for a UJT;
- describe two applications of the UJT;
- name the three leads of the UJT;
- compare the operation of the UJT and the FET;
- describe the conditions required to "turn on" a UJT;
- compare a standard UJT and a programmed unijunction transistor (PUT);
- identify the standard electrical symbol for the PUT;
- describe the function of the Diac;
- identify the most important application of the bidirectional trigger diode (Diac);
- draw the standard electrical symbol for the Diac;
- describe the function of the Triac;
- identify two applications of a Triac;
- draw the standard electrical symbol for the Triac and identify the leads;
- describe the basic operation of a Triac;
- describe the conditions necessary to turn on or turn off a bidirectinal triode thyristor (Triac);
- define IC;
- describe the manufacture and construction of ICs;
- identify common types of IC package styles;
- list the advantages and disadvantages of ICs;
- explain the difference between linear and digital ICs;
- list the applications of linear and digital ICs;
- use a technical manual to look up specifications of ICs;
- construct a working circuit using ICs.

3. Amplifiers

The student should be able to:

- explain the concept of amplifier gain;
- list the types of amplifier gain;
- calculate amplifier of voltage and current gain when appropriate information is given;
- demonstrate the ability to measure the gain of an amplifier stage using the appropriate test instruments;
- list the types of transistor biasing methods;
- compare several types of biasing methods used in transistor amp circuits;
- distinguish between DC and AC transistor amplifiers;

- identify the types of transistor amplifier configurations;
- explain the operation of the common emitter amp;
- identify the amplifier classes of operation and compare each in terms of operation and efficiency;
- explain the process of amplification in an FET amp;
- list the advantages of an FET amp over the bipolar transistor amp;
- describe the function of the vacuum tube;
- explain the operation of diode and triode vacuum tubes;
- point out the similarities between the FET amp and the vacuum tube amp;
- define coupling;
- explain the need for coupling amplifier stages;
- list the methods of coupling amplifier stages;
- identify the advantages of each coupling method;
- define frequency response;
- explain how frequency response affects the overall performance of an amplifier;
- explain the need for an overall "flat" frequency response curve in an amplifier;
- identify factors which affect frequency response;
- define feedback;
- demonstrate how feedback can affect a typical amplifier circuit;
- identify potential sources of unwanted internal feedback in an amplifier circuit;
- explain how negative feedback can be used to extend the frequency response and gain;
- describe the characteristics of a power amplifier;
- compare the purpose and operation of voltage amplifiers and power amplifiers;
- determine the power output of an amplifier stage;
- list the advantages and disadvantages of push-pull amps;
- compare the operation of single-ended power amps and push-pull amps;
- explain the need for heat sinks in high-power circuits;
- define thermal runaway;
- explain how to prevent thermal runaway;
- explain the need for impedance-matching output transformers in tube-type amplifiers;
- compare the output impedance and current-delivering ability of the transistor to that of the vacuum tube;
- list the advantages and disadvantages of using transformers in electronic circuits;
- compare the efficiency of a Class A single-ended transformerless amp with that of a Class B complementary symmetry transformerless amp;
- explain why a driver stage is generally needed when using a power amp output stage;
- explain the function of a phase inverter (or phase splitter);
- identify hazards relevant to working with amplifier circuits;
- outline a general procedure for troubleshooting any amplifier circuit;
- demonstrate skill in the use of appropriate instruments to locate and repair faults in amplifier circuits;
- practice safe procedures in working with amplifier circuits.

4. Electronic Circuits

The student should be able to:

- compare the function and operation of DC and AC amplifiers;
- list the applications and characteristics of a variety of amplifiers;
- list the applications of DC amplifiers;
- identify the applications of AC amplifiers;
- name the three types of rectifier circuits and describe their operation;
- list the advantages and disadvantages of each type of rectifier circuit;
- determine peak and average voltage output from unfiltered rectifier circuits;
- define ripple;
- describe several methods of reducing ripple in power supply output;
- calculate percent ripple in DC power supply output;
- define regulation;
- discuss the need for voltage regulation in power supply circuits;
- calculate percent regulation;
- demonstrate the use of zener diode, transistor, and integrated circuit in voltage regulator circuits;
- describe the purpose and application of voltage multiplier circuits;
- explain the operation of a full-wave voltage doubler circuit;
- explain the need for current overload protection in modern electronic equipment;
- identify common current overload protection circuits;
- demonstrate the ability to locate and repair common faults in defective power supplies;
- define the term oscillator;
- list several oscillator applications;
- discuss the effect of positive and negative feedback;
- summarize the characteristics of a good oscillator;
- compare the output wave shapes of sine wave oscillators and relaxation oscillators;
- identify several common oscillator circuits;
- compare the operation of several oscillator circuits;
- discuss several methods of controlling undesirable oscillations;
- define the term modulation;
- give several examples of circuits which use some form of modulation;
- compare the characteristics, amplitude and frequency modulation;
- draw the basic block diagrams of modern AM and FM radio systems;
- define detector;
- explain the operation of AM and FM detector circuits;
- define reactance;
- explain the importance of reactance in electronic circuits;
- calculate inductive reactance (X_L) and capacitive reactance (X_C) using the appropriate formulas.
- apply Ohm's Law to reactive circuits;
- explain how a voltage-current phase relationship may change in reactive circuits;
- determine voltage distribution and phase angle in series RC and series RL circuits;
- define impedance;
- use the appropriate formula to determine inpedance in reactive circuits;

- define resonance;
- explain the importance of resonance in electronic circuits;
- distinguish between series and parallel resonant circuits;
- explain what "Q" is and how it affects the bandwidth of a tuned circuit;
- calculate the "Q" of a resonant circuit.

5. Radio

The student should be able to:

- briefly outline the early history of radio communications from the 1880's to the early 1990's.
- name the Canadian inventor of voice radio;
- outline the evolution of radio broadcasting in Canada from 1900 to the present;
- name the inventor of the FM system of radio broadcasting and compare his system to AM;
- list several reasons why the superhetrodyne system has gained almost universal acceptance in modern radio broadcasting around the world;
- identify a variety of forms of electromagnetic radiation;
- locate AM and FM radio frequencies on the electromagnetic frequency spectrum;
- explain why radio transmitters are licensed to operate within a specific and limited frequency range;
- identify early types of receivers;
- understand the general theory of operation of the different types of receivers;
- draw block diagrams showing the main parts of the basic types of receivers;
- compare the terms selectivity and sensitivity as they apply to radio receivers;
- list the limitations of the crystal and TRF radios which led to the invention of the superhetrodyne system;
- explain the operation of the AM transmitter;
- outline the theory of operation of the superhetrodyne radio;
- calculate the frequencies found in each stage within the superhet radio;
- identify the problems common within each stage of the AM superhet radio;
- outline a logical procedure for troubleshooting an AM radio;
- demonstrate skill in the use of appropriate test instruments to repair faulty AM radio circuits;
- demonstrate safe practices in the repair of radio circuitry;
- identify the main circuits within an FM radio;
- draw the block diagram of an FM radio transmitter and receiver;
- compare the operation of and signal processing within FM and AM radio systems;
- compare the advantages and disadvantages of FM and AM;
- explain the process by which two FM signals are multiplexed into a single FM stereo broadcast signal;
- describe the process by which an FM radio receiver separates the stereo signal into two distinct channels of sound;
- predict some of the future trends in radio;
- identify the potential uses for radio control in a variety of common appliances;
- discuss the advantages and disadvantages of single sideband radio systems.

6. Optoelectronics

The student should be able to:

- discuss the characteristics of light;
- define the *optical spectrum*;
- describe the characteristics of coherent light;
- understand the advantages and disadvantages of light-wave communication systems;
- describe the construction and operation of light sources and displays;
- discuss the advantages and disadvantages of common display devices and light sources;
- identify several light-reactive devices;
- draw standard electronic symbols for common light-reactive devices;
- explain the principles of operation of the light-reactive devices;
- describe the construction and operation of the photovoltaic cell;
- compare the voltage and current characteristics of photovoltaic cells;
- discuss the future potential of photovoltaic devices;
- outline the historical origins of lightwave communications;
- list several applications of fiber optics;
- list the advantages and disadvantages of fiber optic communication systems;
- name three basic parts of a fiber optic communication system;
- evaluate the future potential of fiber optic systems.

7. Residential Wiring

The student should be able to:

- recall basic residential wiring safety procedures discussed in Electricity/Electronics 101;
- recall basic residential electrical symbols and circuit wiring practices presented in Electricity/Electronics 101;
- describe the care and use of tools and equipment for residential wiring;
- explain the use of clamp-on meters;
- understand the use of conduit benders;
- explain why electrical symbols and notations are used on electrical drawings;
- calculate the occupied floor area of a residential dwelling;
- determine the total load requirements in amperes for general lighting in a dwelling;
- determine the number of lighting branch circuits required for a residential dwelling;
- determine the number of small appliance branch circuits required;
- define *service drop*, *service entrance*, and *underground service*;
- identify the basic parts of the service entrance;
- describe proper placement of a SEP;
- use Electrical Code book to determine conductor size for service entrance drop;
- explain grounding system used for a SEP and bonding of all service entrance equipment;
- describe various types of fuses and circuit breakers;
- explain the operation of fuses and circuit breakers;

- select the proper size fuse or circuit breaker for a particular installation;
- describe the construction and operation of common lighting devices;
- understand the Code requirements relating to the installation of surface mount and recessed lighting fixtures;
- explain the need for forced ventilation in residential dwellings;
- identify several areas in the home which may require forced ventilation;
- describe the types of forced ventilation devices commonly used in the home;
- understand the operation of 4-way switches;
- list examples of where 4-way switches might be used;
- explain the operation of low-voltage remote control systems for lighting;
- identify types of connectors and couplers used on a service entrance;
- identify types of connectors found on ground systems;
- identify types of residential electrical heating systems;
- describe the types of primary heating systems commonly found in residential dwellings;
- explain the operation of secondary heating systems;
- determine the placement of electrical devices on a residential floor plan;
- determine the materials required to wire a complete residential dwelling;
- estimate the cost of materials required for complete wiring of a home;
- determine labor costs for wiring a residence;
- name the various kinds of single-phase induction AC motors;
- draw the schematic symbols for some of the AC motors;
- list several applications for the various single-phase AC motors;
- explain the need for the various starting arrangements in AC motors;
- identify motor enemies and how to limit them;
- identify the types of motor housings;
- explain the basic difference between single-phase and three-phase motors;
- list the two types of three phase motors;
- explain the function of an automatic motor starter.

8. Printed Circuits

The student should be able to:

- define laminate, cladding, artwork, resist, etchant;
- identify the types of laminate materials commonly used in PCB manufacture;
- describe several factors which influence the choice of PCB laminate material;
- prepare an outline of the procedure used in large scale industrial manufacturing of PCBs;
- design an original PCB to be used in a functional electronic circuit;
- compare the silk-screen method and the photo-etch method of PCB production;
- outline the etching process and necessary safety procedures to be followed during this phase of PCB construction;
- describe the steps which the etched PCB must go through in preparation for parts mounting;
- outline some precautions regarding proper component mounting on a PCB;
- demonstrate the ability to etch and assemble a PCB project;
- demonstrate skill in repair of damaged PCBs.

9. Career Explorations

The student should be able to:

- distinguish between occupations and careers;
- identify a variety of occupations related to study of Electricity/Electronics;
- identify skills required for a particular occupation/career;
- outline the training required;
- discuss attitudes for achievement;
- predict the impact of technology on the career/occupation;
- identify major job advertisement sources;
- interpret written job descriptions;
- demonstrate skill in writing resumes and preparing for job interviews.

Electricity/Electronics 301:

1. Student Orientation and Safety

The student should be able to:

- summarize the general outline of the Electricity/Electronics 301 course;
- summarize the method of evaluating students;
- list expectations of behaviour and personal deportment in the lab;
- evaluate hypothetical behaviour in terms of acceptable standards of behaviour;
- outline the layout of the lab;
- identify purposes of tools, machines and equipment;
- understand the importance of safety;
- identify hazards and danger areas;
- recognize the need for appropriate apparel and protective devices in the lab;
- summarize general shop rules and housekeeping practices;
- memorize emergency procedures;
- identify location of safety features in the lab.

2. Components

The student should be able to:

- classify integrated circuits according to construction, operating mode, and packaging;
- compare the characteristics of TTL and CMOS ICs;
- be familiar with the operation of the following linear ICs: - 741 op amp, - 555 timer, -LM386 audio amp;
- demonstrate the operation of common digital logic gate ICs;
- summarize the operation of digital IC memory circuits;
- define piezoelectric effect;
- name the crystal materials which demonstrate the piezoelectric effect;
- list several types of circuits which commonly use piezoelectric crystals;
- draw the standard electrical symbol for a crystal;
- state the advantages of using crystals in oscillators;
- explain how the cut of a crystal affects the natural frequency;
- define crystal fundamental frequency and overtones;
- compare several types of crystal oscillator circuits.

3. Electronic Circuits

The student should be able to:

- draw the standard symbol for the op amp and correctly label the input and output terminals;
- list the characteristics of the ideal op amp;
- list several practical applications of the op amp;
- illustrate the basic circuits inside the op amp by drawing a block diagram;
- identify three basic op amp circuit configurations;
- calculate the voltage gain of op amp circuits;
- construct several simple inverting and non-inverting amps using op amps;
- describe how op amps can be used to construct active filters;
- demonstrate how op amps can be used as ramp generators;
- define and draw periodic waveforms; sinusoidal waveforms, and pulse waveforms;
- list pulse circuit applications;
- demonstrate how the appropriate combination of sine waves can result in square waves, sawtooth waves, or other complex waveforms;
- demonstrate how diodes and transistors can produce a variety of clipping effects on waveforms;
- demonstrate how diode clamper circuits can be used to change the DC reference voltage of a waveform;
- explain why clamper circuits are sometimes called DC restorer circuits;
- describe the characteristics of multivibrator circuits;
- construct astable multivibrator circuits using transistors or ICs;
- calculate frequency and duty cycle of an astable circuit;
- construct monostable circuits using transistors or ICs;
- calculate the output pulse duration of a monostable multivibrator circuit;
- explain why bistable multivibrators are called flip-flops;
- demonstrate the operation of a bistable multivibrator using transistors of digital ICs;
- explain the function and operation of a Schmidtt Trigger.

4. Electronic Communications Systems

The student should be able to:

- describe the evolution of electronic communication systems;
- identify four characteristics of electronic communication systems;
- draw a simple block diagram and explain the function of the basic parts of an electronic communication system;
- give several examples of free-space communication systems and closed-link systems;
- define signal noise;
- explain what is meant by signal-to-noise ratio;
- distinguish between analog and digital encoding systems;
- define the term modulation;
- name and compare the characteristics of digital information encoding;
- compare sine wave modulation techniques;
- explain how sine waves can be converted to digital information;
- explain the difference between open-link and closed-link transmission systems;

- give examples of several types of hand-wired transmission systems;
- name several examples of free-space radiation systems;
- compare the effectiveness of free-space and fiber-optic lightwave communication systems;
- explain the need for frequency and bandwidth regulation in free-space electromagnetic transmission systems;
- outline the processes involved in AM and FM demodulation circuits;
- explain the process by which digital information is decoded;
- identify types of selective filtering of unwanted signals;
- explain the operation of the following output devices: seven segment LED, CRT and liquid crystal display;
- discuss future potential for new types of output display devices;
- give examples and explain the operation of several types of electronic information storage;
- name several types of magnetic information storage systems;
- describe recent developments in information storage technology.

5. Television

The student should be able to:

- identify the portion of the electromagnetic frequency spectrum allocated to TV broadcast transmission;
- compare the bandwidth allocations for a TV channel with that of AM radio stations and FM radio stations;
- define audio and video;
- identify the type of modulation used for audio and video in television broadcast systems;
- describe the limitations of line-of-sight television transmission;
- draw a simple block diagram illustrating the main parts of a television broadcast transmitter and receiver;
- summarize the North American monochrome television broadcast standards;
- identify and explain the differences between various television systems which use cable distribution;
- briefly explain how satellites can be used to provide wide-area television coverage;
- discuss the processes involved in home video tape recording systems;
- describe the basic operation of video disc systems;
- compare the operation of one-tube and three-tube types of projection television systems;
- discuss the operation of television video game accessories;
- describe the operation of interactive video text systems using the public telephone network;
- list the principles involved in scanning the television picture;
- describe the picture qualities important in television;
- explain the difference between the television picture field and frame;
- discuss the function and importance of syncronization and blanking signals;
- name the most commonly used television camera tubes and compare their operation;
- compare the operation of a B & W video camera and a color camera;
- describe the process by which sync signals are mixed with video signals at the television broadcast station;

- illustrate the basic construction of a picture tube;
- define the term deflection angle and explain how it is measured;
- explain the numbering system used for picture tube identification;
- outline the function of the aluminized phosphor screen backing used in modern CRTs;
- understand the function and operation of the electron gun assembly;
- describe the safety precautions which should be followed when handling picture tubes;
- compare electromagnetic and electrostatic deflection systems;
- explain the function of the shadow mask;
- outline some of the common troubles associated with picture tubes and discuss how to deal with them;
- make a drawing which illustrates the basic shape of the amplitude modulated video carrier wave;
- explain the process by which the modulated video carrier is converted into the composite video signal;
- make a drawing to illustrate the composite video signal;
- list the advantages of negative picture transmission;
- state the frequencies for video line rate, field rate, and frame rate;
- discuss the importance of the average or DC component of the video signal;
- draw a functional block diagram of a monochrome television receiver and explain the function of each block;
- name and identify the purpose of the external controls on a monochrome television;
- explain the process by which television channels are tuned;
- describe how picture-tube high voltage is produced;
- explain the action of the automatic gain control (AGC) circuit;
- explain or demonstrate how to align a B & W receiver using an oscilloscope and RF sweep generator;
- apply appropriate troubleshooting skills to identify symptoms, isolate faulty circuits, and make repairs to defective parts in televisions;
- demonstrate safe practices in the repair of television circuitry;
- explain the advantages of cable television distribution systems;
- outline the main parts of cable distribution systems;
- explain why cable television station frequencies may differ from standard television broadcast frequency allocations;
- explain the purpose of cable television converters;
- compare NTSC system standards to other systems.

6. Digital Concepts and Microprocessors

The student should be able to:

- list the advantages of digital circuits in electronic equipment;
- identify the semiconductor devices used in digital circuits;
- name the two main IC families used in digital circuits and discuss their differences in construction;
- compare the characteristics of TTL and CMOS ICs;
- define the term fanout;
- describe the output wave form from digital circuits;

- compare serial and parallel data transfer;
- name the number systems most commonly used in digital circuits;
- convert decimal numbers to binary and hexadecimal;
- identify the advantage of using binary numbers in digital electronic systems;
- distinguish between standard binary and binary coded decimal (BCD);
- describe the operation of digital IC encoders and decoders;
- name common logic gates and draw their standard symbols;
- explain the function of each of the basic logic gates;
- explain why logic gates are referred to as "decision making" circuits;
- develop and explain the importance of truth tables for the common logic gates;
- compare positive and negative logic;
- write Boolean logic expressions for the various logic gates;
- simplify logic circuit expressions using Boolean algebra;
- demonstrate the operation of common logic gates by constructing experimental circuits;
- define sequential logic circuit;
- name the simplest digital memory circuit;
- draw the symbols for common flip-flops;
- compare the characteristics of common flip-flops;
- demonstrate how flip-flops can be made from combinations of simple logic gates;
- define and explain the purpose of a register;
- compare the operation of serial and parallel shift registers;
- define binary counter;
- explain the operation of asynchronous and synchronous counters;
- demonstrate the operation of binary and BCD counters using J-K flip-flops;
- demonstrate the use of IC counters as frequency dividers;
- explain the importance of clock pulses in sequential logic circuits;
- demonstrate how to construct an astable multivibrator clock circuit using digital logic gates;
- draw a block diagram showing the main parts of a digital computer;
- name several examples of computer input and output devices;
- identify the main types of computer memory circuits;
- explain the difference between volatile and nonvolatile memories;
- compare PROMs and EPROMs;
- list several external bulk memory devices;
- describe the operation and advantages of several types of external bulk memory devices;
- explain the function of the microprocessor unit (MPU) within the digital computer;
- draw a block diagram and explain how instructions and data are processed within the MPU;
- define program, algorithm, flow chart, loop, coding, and machine language program;
- write a simple machine language program and explain or demonstrate how the computer processes each instruction within the program;
- apply safe practices in troubleshooting digital circuits;
- demonstrate appropriate skill in troubleshooting digital circuits.

7. Fiber Optics

The student should be able to:

- define light;
- compare the concept of geometrical optics to physical optics;
- define the terms reflection, refraction, absorption, and diffusion;
- demonstrate the effect of simple concave and convex lenses on light beams;
- describe the function of optical components such as the prism and filters;
- explain the operation of light-emitting diodes;
- explain the meaning of coherent light;
- explain the operation of the ruby laser;
- explain the operation of laser diodes;
- discuss the history and evolution of fiber optics;
- compare the methods of light transmission (propagation) within optical fibers;
- list types of losses that occur in fiber optics systems;
- describe the construction of optical fibers;
- list the types of materials used to manufacture optical fibers;
- explain how the construction of a fiber optic LED is different from a standard LED;
- describe the function of an optical receiver;
- identify the major photodetector devices and explain their operations;
- draw a block diagram showing the basic parts of a simple photodetector receiver circuit;
- identify three classifications of data transmission standards for fiber optics communication systems;
- describe the basic function of a repeater in a long-link fiber optics system.

8. Robotics/Interfacing

The student should be able to:

- describe early inventions which led to the evolution of the modern robot;
- define robot;
- describe how robots are currently used in industry;
- define controller, manipulator, actuation, degrees of freedom;
- distinguish between low-technology and high-technology robots;
- describe examples of feedback control systems;
- explain how robots can be equipped with sensors for heat, light, pressure, and sound;
- describe how various sensor components operate;
- outline the process of voice recognition by a robot;
- name the joints found in robotic arms;
- compare the number of movements possible for a robotic arm with the number of movements possible for the human arm;
- explain the function of the manipulator and the gripper;
- identify a variety of robotic power systems;
- compare the operation of stepper motors and standard DC motors;
- predict future uses for robots in the home and in industry;
- describe some of the social implications of widespread use of robots in industry.

9. Residential Wiring

The student should be able to:

- recall basic residential wiring safety procedures discussed in Electricity/Electronics 101;
- recall basic residential electrical symbols and circuit wiring practices presented in Electricity/Electronics 101;
- describe the care and use of tools and equipment for residential wiring;
- explain the use of clamp-on meters;
- understand the use of conduit benders;
- explain why electrical symbols and notations are used on electrical drawings;
- calculate the occupied floor area of a residential dwelling;
- determine the total load requirements in amperes for general lighting in a dwelling;
- determine the number of lighting branch circuits required for a residential dwelling;
- determine the number of small appliance branch circuits required;
- define service drop, service entrance, underground service;
- identify the basic parts of the service entrance;
- describe proper placement of a SEP;
- use Electrical Code book to determine conductor size for service entrance drop;
- explain the grounding system used for a SEP and bonding of all service entrance equipment;
- describe various types of fuses and circuit breakers;
- explain the operation of fuses and circuit breakers;
- select the proper size fuse or circuit breaker for a particular installation;
- describe the construction and operation of common lighting devices;
- understand the Code requirements relating to the installation of surface mount and recessed lighting fixtures;
- explain the need for forced ventilation in residential dwellings;
- identify several areas in the home which may require forced ventilation;
- describe the types of forced ventilation devices commonly used in the home;
- understand the operation of 4-way switches;
- list examples of where 4-way switches might be used;
- explain the operation of low-voltage remote control systems for lighting;
- identify types of connectors and couplers used on a service entrance;
- identify types of connectors found on ground systems;
- identify types of residential electrical heating systems;
- describe the types of primary heating systems commonly found in residential dwellings;
- explain the operation of secondary heating systems;
- determine the placement of electrical devices on a residential floor plan;
- determine the materials required to wire a complete residential dwelling;
- estimate the cost of materials required for complete wiring of a home;
- determine labor costs for wiring a residence;
- name the various kinds of single-phase induction AC motors;

. draw the schematic symbols for some of the AC motors;
. list several applications for the various single-phase AC motors;
. explain the need for the various starting arrangements in AC motors;
. identify motor enemies and how to limit them;
. identify the types of motor housings;
. explain the basic difference between single-phase and three-phase motors;
. list the two types of three-phase motors;
. explain the function of an automatic motor starter.

10. Career Explorations

The student should be able to:

. distinguish between occupations and careers;
. identify a variety of occupations related to the study of Electricity/Electronics;
. identify skills required for a particular occupation/career;
. outline the training required;
. discuss attitudes for achievement;
. predict the impact of technology on the career/occupation;
. identify major job advertisement sources;
. interpret written job descriptions;
. demonstrate skill in writing resumes and preparing for job interviews.

electricity/electronics 101

ELECTRICITY/ELECTRONICS 101

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STUDENT ORIENTATION AND SAFETY - EE101-01

Major Objectives: To understand the structure of the 101 Electricity/Electronics course and method of evaluation.
To understand general shop safety and procedures.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. EXPECTATIONS AND EVALUATION		
The student should be able to:		
1. Summarize the general outline of the Electricity/Electronics 101 course.	Provide students with a course outline or overview. Discuss general topics to be covered in the course and explain how the learning will take place.	
2. Recognize the relationship between junior-and senior-high Electricity/Electronics.	Explain the difference between junior-high and senior high-programs, highlighting the goals of senior-high Electricity/Electronics.	
3. Summarize the method of evaluating students.	Discuss evaluation policy and examination policy. Encourage students to monitor their own progress.	
4. List expectations of behaviour and personal deportment in the lab.	Discuss attendance policy. Outline the procedure to be followed in case of absence or late arrival. Explain expectations for conduct and behaviour in the lab.	
5. Evaluate hypothetical behaviour in terms of acceptable standards of behaviour.	Describe hypothetical classroom or lab situations and ask students to judge the behaviour described.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
B. ORGANIZATION OF LAB		
The student should be able to:		
1. Outline the layout of the lab.	Provide a tour of the lab with a general introduction to layout, equipment and processes.	
2. Identify purposes of tools, machines and equipment.	Provide orientation only at this time. Simply acquaint the students with general processes which can be accomplished using the facilities available.	
C. SAFETY AWARENESS		
The student should be able to:		
1. Understand the importance of safety.	Invite guest speaker(s) from industry, Worker's Compensation, or Workplace, Safety and Health to make students aware of the importance of safety on the job and in the lab.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Identify hazards and danger areas.	Discuss safety hazards in the lab. Make students aware of the location and marking of danger areas. Point out that where hazards can not be removed, students must develop an attitude of safety consciousness while working around them.	
3. Recognize the need for appropriate apparel and protective devices in the lab.	Discuss appropriate apparel for the lab. Give examples of inappropriate apparel and ask students to discuss the hazards. Point out protective devices found in the lab and discuss their use.	
4. Summarize general shop rules and housekeeping practices.	Provide an outline of housekeeping procedures that are to be followed. Discuss general shop rules that students must follow.	
5. Memorize emergency procedures.	Familiarize students with divisional safety policies. Discuss emergency procedures such as fire and accident.	
6. Identify safety features in the lab.	Make students aware of the location of: - first aid box - fire blanket - fire extinguisher - panic button - eye wash station - goggles - venting	

TOOLS AND SOLDERING TECHNIQUES - EE101-02

Major Objectives: To understand the safe use of tools commonly found in the Electricity/Electronics lab.
To develop skill in soldering electrical components and wires.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. TOOLS The student should be able to:		
1. Identify the tools commonly used in the field of Electricity/ Electronics.	Have students complete tool identification sheet and tool application sheet. Make students aware that when appropriate tools are used, work is done more efficiently and safely. Point out that industrial productivity is increased by improved work efficiency.	Tools 1. Pliers & Wire Cutters - Needlenose - Diagonal Wire Cutters - Side-Cutting - Other Types of Pliers . Vice Grip . Slip Joint 2. Screwdrivers & Nut Drivers - Standard (slot) - Phillips - Robertson - Nut Drivers 3. Awls & Punches - Marking Awl - Center Punch - Chassis Punch 4. Cutting and Forming Tools - Snips - Sheet Metal Squaring Shear - Box & Pan Brake - Drill Press 5. Wrenches & Other Tools - Adjustable Wrench - Allen Keys - Wire Strippers - Crimping Tools

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Demonstrate appropriate skill and safety in the use of common handtools.	Demonstrate various handtool uses at appropriate times in course work.	
B. SOLDER & SOLDERING TECHNIQUES The student should be able to:		
1. Identify types of solder.	Discuss the reasons why solder is used in electrical work. Emphasize the need for selecting the best type of solder for the job. Compare acid core and rosin core solder.	Types of Solder 1. Acid Core 2. Rosin Core
2. List important characteristics of each.	Point out that solder can also be classified by percentage of lead and tin. Discuss the strength and conductivity of solders.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Describe the purpose of flux.	Discuss various types of flux. Point out that acid flux is never used in electrical work. Point out that flux may be used in paste form, which is applied directly to the work, or it can be used "as is" in cored solder.	Purpose of Flux To clean surfaces to be soldered and to help solder adhere.
4. Identify the appropriate tools used for soldering.	Demonstrate proper soldering techniques using appropriate tools.	Soldering Tools 1. Solder gun or iron 2. 60-40 rosin core solder 3. Needlenose pliers 4. Wire strippers 5. Heat sink tool
5. Demonstrate correct soldering techniques.	Provide an opportunity for students to practice soldering skills.	
6. Inspect solder joints.	Point out three things to look for when inspecting a solder connection: (1) color = silvery and shiny (2) texture = smooth, not rough (3) shape = tapered edges, not balled	
7. Remove solder and replace soldered components in an actual circuit.	Discuss methods of removal of solder. (1) solder wick (2) solder sucker Point out that some components can be damaged by excessive heat. Demonstrate the use of a heat sink tool.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
8. Understand how to care for soldering tools.	Students' understanding of the care of tools should include an understanding of tip cleaning and tinning, troubleshooting, and repair of defective guns and irons.	
9. Demonstrate safety in soldering.	Stress hazards of soldering: (1) burns (2) poor ventilation	

D.C. THEORY - EE101-03

Major Objectives: To understand the relationship between voltage, current, and resistance in simple parallel circuits.
To understand how magnetism and electricity are related.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. CURRENT		
The student should be able to:		
1. Define atom, proton, electron.	Discuss the atomic structure of matter. Provide students with an illustration of an atom.	Getting Started in Electronics -- Mims (Radio Shack) Indivdual Learning Program; Heathkit Atom The smallest portion of an element that still retains the properties of that element. Proton(+) A relatively large, positively charged particle found in the nucleus of an atom. Electron(-) An extremely small, negatively charged particle found orbiting or vibrating outside the nucleus of the atom.
2. Draw a model of an atom.	Stress that our model of the atom is based on well researched theory. However, due to its extremely small size, no one has actually seen an atom.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Identify the basic parts of an atom, and identify the electrical charge of each.	Point out that atoms which occur in their pure form in nature have a neutral charge because the number of protons and electrons are equal and opposite in charge.	
4. Define neutral atom and free electron.	Stress that as long as the number of electrons and protons are equal, the atom remains neutral. However, some atoms easily give up some electrons. Point out that loss of electrons affects the net charge on the atom.	Neutral Atom An atom which has an equal number of negative electrons and positive protons. Free Electron An electron which is not bound securely to an atom, thus free to move.
5. Explain the law of electrical charges.	Make students aware of importance of the law of charges in both static electricity and current electricity.	Law of Electrical Charges Unlike charges attract; like charges repel.
6. Distinguish between conductors and insulators.	Discuss and ask students to define a conductor. Demonstrate a variety of common conductors and insulating materials.	Conductors Materials (generally metals) whose outer electrons can easily be moved. Insulators Materials whose outer electrons cannot easily be moved.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
7. Define current.	Discuss the difference between random drift of electrons and electrical current.	Current The rate of flow of electrons through a conductor.
8. Illustrate the difference between conventional current and electron current flow.	Point out that conventional current flow is opposite to electron current flow. Discuss the historical evaluation of conventional and electron current flows.	Conventional Current "+" charges move from the positive terminal of the source and flow through the circuit towards the negative terminal. Electron Current "-" flow from the negative terminal of the source and travel through the circuit toward the positive terminal.
9. State the units of measurement for electrical current.	Stress that in most solid state circuits today, the current flow is very small. Thus, units of milliamp and microampere are used frequently.	Units of Measurement Ampere or Amp Milliamp = 0.001 Amp Micro Amp = 0.000 001 Amp

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
B. VOLTAGE The student should be able to:		
1. Define: electromotive force, potential difference, voltage and volt.	Point out that the terms, electromotive force, potential difference, and voltage, are often used interchangeably. Stress that it is voltage which causes electrical current to flow.	Electromotive Force (emf) The pressure or force which causes current to flow in a circuit. Potential Difference The difference in electrical charges (or voltages) between two points in a circuit. Voltage The measure of potential difference between negative and positive points in a circuit. Volt The unit of measure of electrical pressure or potential.
2. List general sources of electricity and give examples of each.	Demonstrate a variety of sources of electricity. Discuss the advantages and limitations of each type of electrical source. Ask students to discuss the future potential of each of the six sources of electricity.	The Six Sources of Electricity 1. Friction: lightning, static electricity. 2. Chemical: cells and batteries. 3. Magnetism: generators and alternators. 4. Heat: thermocouple and thermopile.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
		5. Light: photovoltaic cell (solar cell) 6. Pressure: crystal microphones and earphones.
3. Distinguish between voltage rise and voltage drop.	Point out that voltage rise is always equal to voltage drop.	Voltage Rise Voltage caused by source of electrical energy. Voltage Drop Voltage used up by loads in circuit.
C. RESISTANCE The student should be able to:		
1. Define electrical resistance.	Discuss and ask students to illustrate the effect of resistance in an electrical circuit.	Electrical Resistance The opposition to the flow of electrons in a circuit.
2. State the unit of measurement for resistance.	Make students aware that resistance can be measured with a device called an ohmmeter.	Unit of Measure of Current Ohm: Larger units of resistance include the kilo ohm (1 000 ohms) and the mega ohm (1 000 000 ohms).

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Explain the meaning of resistivity and conductance.	Define resistivity and point out that is the reciprocal of resistance. Point out that the unit of conductance is the ohm.	Resistivity The relative ability of a material to oppose the flow of electrical current (eg; carbon has greater resistivity than copper). Conductance The reciprocal of resistance.
4. Demonstrate skill in using the ohmmeter to measure resistance.	Allow students to become familiar with operation of digital and analog meters by practicing resistance measurements on a number of components.	
5. Demonstrate skill in using various testing devices to measure continuity.	Define continuity. Demonstrate the use of various continuity testing devices. Have students demonstrate their skill in testing continuity of bulbs, fuses, heating elements, and multiwire cables.	Continuity The condition of a circuit when it is complete and current can flow. Continuity Test A check to see if a particular circuit is continuous (unbroken).

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
D. OHM'S LAW & WATT'S LAW The student should be able to:		
1. State Ohm's Law and explain its importance.	Point out that Ohm's Law derives its name from the German physicist who first explained the mathematical relationship among voltage, current, and resistance. Discuss the importance of Ohm's Law.	Ohm's Law The mathematical relationship among voltage, current and resistance in an electrical circuit.
2. Write, using appropriate letter symbols, the three forms of Ohm's Law.	Make students aware of both the S.I. metric form and the traditional form of Ohm's Law. Demonstrate an organized method for problem solving with Ohm's Law.	Traditional E=IxR I=E/R R=E/I SI $V=A\times\Omega$ $A=\frac{V}{\Omega}$ $\Omega=\frac{V}{A}$
3. Solve problems using Ohm's Law.	Provide worksheets to practice calculations. Also, provide hands-on experiments with circuits which demonstrate Ohm's Law relationships.	
4. Define power and watt.	Discuss and define power. Explain the relationship between power and Ohm's Law.	Power The rate at which energy is consumed or work is done. Watt Unit of power.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
		Units of Power 1. Watt 2. Kilowatt 3. Milliwatt 4. Megawatt
5. State Watt's Law and explain its importance.	Demonstrate how Watt's Law can be used to calculate voltage or current.	Watt's Law The mathematical relationship among current, voltage, and power in an electrical circuit.
6. Write, using appropriate letter symbols, the three forms of Watt's Law.	Have students write the three formulas for Watt's Law. Point out the similarity to Ohm's Law.	Traditional $P = I \times E$ $I = P/E$ $E = P/I$ SI $W = A \times V$ $A = \frac{W}{V}$ $V = \frac{W}{A}$
7. Solve problems using Watt's Law.	Provide practice problems to develop skill in solving circuit problems using Watt's Law.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
E. SERIES AND PARALLEL CIRCUITS The student should be able to:		
1. Define series circuit, parallel circuit.	Discuss common circuits using series or parallel connections.	Series Circuit Any circuit having only one path. Parallel Circuit Any circuit having more than one path.
2. State the effects of connecting batteries and cells in series and parallel.	Demonstrate series and parallel battery connections. Point out that parallel batteries can deliver more current over a longer period of time when compared to series batteries. Explain that connecting batteries in series results in greater voltage.	
3. State the effects of connecting bulbs in series and in parallel.	Discuss and then demonstrate series and parallel bulb circuits. Point out the multi-branch nature of parallel circuits. Show that series bulbs result in voltage division. Explain that in series, if one bulb burns out or is removed from the circuit, all current stops and the remaining bulbs stop working. Provide hands on experiences wiring series and parallel circuits.	In a parallel circuit, if one bulb burns out or is removed from the circuit, the remaining bulbs continue to operate.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS	
4. Show how voltage is divided in a series circuit.	Provide hands-on lab experiments to allow students to discover series and parallel relationships. Stress the laws for current, voltage and resistance in series and parallel circuits.	Series	Parallel
		$V_T = V_1+V_2+V_3$	$V_T = V_1+V_2 + V_3$
		$A_T = A_1=A_2=A_3$	$A_T = A_1+A_2+A_3$
		$R_T = R_1+R_2+R_3$	R_T = R/N (if all Resistors are same size) Where R = Value of Resistor N = Number of Resistors OR $R_T= \frac{R_1 \times R_2}{R_1 + R_2}$ OR $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
5. Describe how current is divided in a parallel circuit.	Make students aware that the total current in a parallel circuit can be determined by adding the branch currents.	
6. Calculate total resistance in series, parallel and combination circuits.	Discuss how total circuit resistance is affected by connecting resistors in series and parallel. Provide practice problems for solving total resistance in a variety of series and parallel circuits.	
7. Solve problems involving unknown voltage, current, and resistance in series and parallel circuits.	Demonstrate the application of simple series and parallel circuits relationships to solve problems involving voltage, current, resistance, or power.	
8. Solve problems involving power and parallel circuits consumed in series.		

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
F. MEASURING ELECTRICAL QUANTITIES The student should be able to:		
1. Identify types of meters.	Point out that meters can be classified by their circuitry (digital or analog) or by their function (voltmeter, ammeter, ohmmeter, or multimeter). Introduce the meter symbols so that students will recognize them in schematics.	-Ⓥ-= Voltmeter -Ⓐ-= Ammeter -(Ω)-= Ohmmeter
2. Describe the uses of different types of meters.	Emphasize that voltmeters are always connected in parallel with the circuit, while ammeters and milliammeters are always connected in series with the circuit. Stress that ohmmeters must never be used in a "live" circuit.	
3. Demonstrate skill in the use of voltmeter, milliammeter, and ohmmeter.	Have students practice use of meters in "safe" circuits where only low voltages may be encountered.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
G. MAGNETISM The student should be able to:		
1. Define magnetic field, flux lines, pole.	Discuss the relationship between electricity and magnetism. Emphasize the widespread use of magnetism in electrical and electronic circuits. Ask students to list devices which either use or produce magnetism.	**Magnetic Field** The area of attraction that surrounds a magnet. **Flux Lines** Invisible lines of magnetic force in a magnetic field. **Pole** The end of a magnet. Every magnet has a north pole and a south pole.
2. State the basic law of magnetism.	Demonstrate and have students discuss the law of magnetism.	**Law of Magnetism** Like poles repel, opposite poles attract.
3. Distinguish between permanent magnets and electromagnets.	Make students aware of the difference between permanent magnets and electromagnets.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
4. Prove that electric current produces a magnetic field around a conductor.	Demonstrate a magnetic field around a wire by placing a compass or iron filings nearby while D.C. flows through the wire. Reverse the current direction and show what happens to the compass needle or iron filings.	
5. Describe methods of increasing the magnetic field strength surrounding a coil.	Define inductor. Discuss ways of making a coil produce a stronger magnetic field.	Inductor Coil of wire.
6. Explain how relays and solenoids work.	Define electromechanical. Point out that relays and solenoids are electromechanical devices.	Electromechanical Any device which converts electrical energy into mechanical movement.
7. Give examples of applications of relays and solenoids.	Discuss the use of relays and solenoids in motors, pin ball machines, automobiles, etc.	
8. Define inductance, electromagnetic induction, and counter emf.	Ask students to discuss and define inductance, electromagnetic induction, and counter emf. Emphasize that these terms generally refer to the action of coils.	Inductance The ability to induce a voltage in a conductor when current rises or falls. Electromagnetic Induction A current produced within a wire as a result of the movement of a magnetic field near the wire.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
		Counter emf Voltage produced which is in opposition to the effect which caused it.
9. State the three things needed for electromagnetic induction.	Demonstrate electromagnetic induction by moving a magnet near a coil connected to a sensitive meter. Have students observe how the direction of the movement of the magnetic field affects the polarity of the resulting current.	Things Required for Electromagnetic Induction 1. Conductor 2. Magnetic field 3. Relative motion between conductor and magnetic field
10. Explain how self-induced voltages are produced.	Point out that rapidly collapsing magnetic fields can develop extremely high voltages in inductors.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
H. MOTORS AND GENERATORS The student should be able to:		
1. Demonstrate motor action and explain the reaction between magnetic fields which causes it.	Point out that motor action is found in many devices besides motors. Some examples include speakers and earphones and servos. Discuss the basic parts of the simple DC motor. Demonstrate the operation of the DC motor.	Rosenberg, *Electric Motor Repair*, *Holt, Reinhardt Winston Publishing* Motor Action Mechanical motion which results from the attraction and/or repulsion of magnetic fields.
2. Describe the operation of a generator.	Discuss the basic parts of an electric generator. Point out the difference between a DC generator and an AC generator. Examine the operation of a simple electric generator.	
3. List the types of electric motors and outline their applications.	Have students discuss uses for electric motors and generators.	Types of Motors 1. Series (Universal) 2. Shunt or Parallel 3. Compound 4. Independently Excited

PASSIVE COMPONENTS - EE101-04

Page ____

Major Objectives: To identify components and to represent them using symbols in schematic drawings.
To understand the function, application and testing of common components.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. COMPONENT IDENTIFICATION		
The student should be able to:		
1. Identify common components found in electrical circuits.	Provide an opportunity for students to view and discuss common circuits such as portable radios, stereo systems, power supplies, televisions, computers, etc. Point out the most common components found in all the circuits.	Common Components 1. Battery 2. Printed Circuit Board 3. Dry Cell 4. Coil 5. Wire 6. Transformer 7. Fuse 8. Diode 9. Switch 10. LED 11. Resistor 12. Transistor 13. Capacitor 14. Integrated Circuit
2. Draw the appropriate schematic symbol for each of the common components.	Point out that electrical circuits may be drawn as block diagrams, pictorials, or schematics. Discuss the need for each type of circuit drawing. Highlight the use of schematics and symbols and provide students with standard symbols for components listed above.	
B. RESISTORS & COLOR CODE		
The student should be able to:		
1. Describe the functions of fixed and variable resistors.	Indicate that resistors are one of the most commonly used components in modern electronic circuits. Discuss resistor function.	Function of resistors To limit current and reduce voltage.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Draw the symbols for fixed and variable resistors.	Discuss the need for variable resistors. Make students aware of their use in volume controls and other applications. Ask students to draw symbols for fixed and variable resistors. Point out resistors in schematic circuits.	
3. Determine ohmic value of any color-coded resistor by using the color bands.	Demonstrate the manner in which resistors are "read". Discuss the resistor color code. Provide a group game-type activity to assist in the rapid memorization of the resistor color code. Allow students hands-on experience in learning to read resistor color bands.	
4. Determine the wattage of any color-banded resistor.	Present a display of actual resistors consisting of a variety from 1/8 watt to 5 watt. Encourage students to develop an awareness of the common sizes of resistors.	
5. Determine the tolerance of any color-banded resistor.	Demonstrate how to determine the tolerance of any color coded resistor. Compare indicated tolerance range to actual measured value of resistance.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
6. Connect resistors in series and in parallel.	Point out that connecting resistors in series increases total resistance, while parallel resistors result in lower resistance.	
7. Measure ohmic value of resistors using an ohmmeter.	Review appropriate use of ohmmeter. Stress that the ohmmeter should never be used in a "live" circuit.	
8. Measure total resistance in series and parallel circuits.	Provide sample circuits containing series and parallel resistors. Have students measure total resistance of circuits and discuss results.	
C. CAPACITORS		
The student should be able to:		
1. Describe the function of capacitors.	Demonstrate that capacitors can store electrical energy.	Function of a Capacitor To store electrical energy.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Identify common styles of capacitors.	Point out the following capacitor types in actual circuits: 1. ceramic disc 2. paper 3. mica 4. mylar 5. electrolytic 6. variable	
3. Draw the symbols for fixed capacitors and variable capacitors.	Point out that capacitors are sometimes "ganged" together. Draw the symbol for a ganged capacitor and refer to one in a schematic.	
4. Describe the construction of common types of capacitors.	Compare construction of paper, mylar, ceramic disc, tantalum, and electrolytic capacitors.	
5. Determine capacitance and breakdown voltage of capacitors.	Explain the various systems used for marking capacitor sizes. Provide an opportunity for students to practice skill in determining capacitor size by color-coded markings. Have students solve conversion problems.	Basic Units for Capacitance = Farad Metric prefixes include "micro", "pica" and "nano".

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
6. State factors which affect capacitance.	Discuss factors which affect capacitance value.	Factors Which Affect Capacitance 1. Size of the plates. (overlapping plate area) 2. Distance between plates. 3. Insulating (dielectric)
7. Connect capacitors in series and in parallel.	Point out that connecting capacitors in series results in less capacitance, while capacitor in parallel increase total capacitance of any circuit.	
8. Calculate total capacitance in series and in parallel circuits.	Discuss the following formulas: $C_{T\ (\text{Parallel})} = C_1 + C_2 + C_3$ $C_{T\ (\text{Series})} = C/N$ OR $C_{T\ (\text{Series})} = \frac{C_1 \times C_1}{C_1 + C_2}$ OR $\frac{1}{C_{T\ (\text{Series})}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
9. Explain the relationship between voltage and current in capacitor circuits.	Discuss why voltage and current appear out-of-phase in capacitor circuits. Explain current leads voltage in a capacitive circuit.	
10. Test capacitors using an ohmmeter.	Demonstrate how to determine if a capacitor is open or shorted. Discuss leakage within capacitors. Compare electrolytic vs tantalum vs mica.	
11. Determine tolerances of a capacitor.	Point out that some manufacturers indicate capacitor tolerance by color band.	
D. SWITCHES The student should be able to:		
1. Classify switches by their construction.	Demonstrate the operation of a variety of switches.	Types of Switches 1. Toggle 2. Slide 3. Rotary 4. DIP 5. Push-button

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Identify the symbols and abbreviations for common switches.	Discuss the meaning of various switch abbreviations (ie: PBNO = Push Button Normally Open).	Types of Switches 1. Toggle 2. Slide 3. Rotary 4. DIP 5. Push-button
3. Test switches.	Demonstrate the use of the ohmmeter and/or continuity tester to determine if a switch is operating as intended. Provide hands-on experience for connecting a variety of switches in working circuits.	Switch Abbreviations 1. SPST 2. SPDT 3. DPST 4. DPDT 5. PBNO 6. PBNC
E. BULBS		
The student should be able to:		
1. Define incandescent and fluorescent.	Discuss the advantages and disadvantages of each type. Compare efficiency, cost, etc.	Incandescent To glow with intense heat. Fluorescent To produce light when acted upon by radiant energy.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Explain the construction and operation of fluorescent and incandescent bulbs.	Compare the construction and operation of common incandescent and flurrescent systems.	
3. Explain the operation of ionized gas bulbs.	Demonstrate the operation of neon bulbs such as Ne-2.	
4. Test incandescent bulbs using an ohmmeter.	Demonstrate the appropriate method for testing incandescent bulbs. Stress the need to remove the bulb from the circuit to avoid the possibility of shock or damage to meter.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
F. BATTERIES & CELLS The student should be able to:		
1. State the common types and sizes of dry cell batteries.	Distinguish between a "cell" and a "battery". Point out that the popularity of batteries and cells as portable power supplies has increased in recent years due to the reduced energy requirements of modern solid state circuitry. Show examples of common sizes of cells.	Common Dry Cell Sizes 1. AAA 3. C 2. AA 4. D. Cell A single chemical unit consisting of two electrodes plus an electrolytic chemical. Battery Two or more cells grouped together.
2. Compare several common types of cells.	Discuss differences between NiCad, mercury, alkaline, and carbon-zinc cells. Point out that while NiCad batteries and cells are rechargable, other types are not.	
3. Identify the positive and negative terminals on common cells and batteries.	Provide a variety of common dry cells and batteries and ask students to identify positive and negative terminals. Discuss.	
4. Test batteries and cells using a voltmeter as a battery checker.	Demonstrate testing procedure for batteries and cells. Stress that for most accurate results, the cell or battery should be tested under load, operating in a typical circuit.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
G. FUSES AND CIRCUIT BREAKERS The student should be able to:		
1. Explain the purposes of fuses and circuit breakers.	Point out common uses of fuses and circuit breakers in TVs, home wiring panels, automobiles, etc.	Variety of fuse styles and circuit breakers. Ground Fault Circuit Interruptor (GFCI)
2. Identify common fuse/circuit breaker styles.	Discuss advantages and disadvantages of fuses vs circuit breakers. Point out ampere rating of fuses and circuit breakers. Stress that circuit breakers and fuses should never be replaced with higher-rated devices. Discuss the use of GFCI devices in the home.	
3. Indicate the ampere rating of common fuses/circuit breakers.		
4. Test fuses/circuit breakers using an ohmmeter.	Demonstrate methods for testing fuses and circuit breakers commonly found in small appliances. Discuss safety in installation and removal of fuses from fuse boxes, etc.	
5. Replace defective fuses/circuit breakers.	Provide hands-on experience in safely replacing defective fuses and circuit breakers.	

AC THEORY - EE101-05

Major Objectives: To understand what alternating current (AC) is and how it compares to direct current (DC).
To understand what effect capacitors and inductors have in AC circuits.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. AC vs DC The student should be able to:		
1. Define alternating current, direct current, sine wave, hertz.	Give examples of circuits which typically require AC and others which require DC.	Alternating Current A current which is continuously changing amplitude and periodically changes direction. Direct Current A current which has a constant amplitude and direction. Sine Wave The characteristic shape of an AC waveform. Hertz A unit of frequency in cycles per second.
2. Explain the difference between AC and DC.	Demonstrate, using oscilloscope and power supply.	
3. Describe how alternating current flows in a circuit.	Make students aware of the nature of electron movement in an alternating current circuit.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
4. Explain the characteristics of a sine wave.	Discuss the importance of the following sine wave characteristics: period, amplitude, and frequency. Draw a sine wave and point out that a sine wave is simply a graph showing the magnitude and directions of an alternating current.	Characteristics of Sine Wave: Period The amount of time required to complete one cycle of AC. Amplitude The height of the sine wave. Frequency Number of cycles per second.
B. GENERATING AC The student should be able to:		
1. Identify the basic parts of an AC generator.	Compare operations of AC & DC generators.	Basic parts of an AC Generators 1. Armature 2. Slip rings 3. Brushes 4. Magnetic field
2. Describe the operation of a simple AC generator.	Have students investigate the operation of AC generators. Point out the need for slip rings in an AC generator.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
C. MEASURING AC The student should be able to:		
1. Compare peak voltage, peak-to-peak voltage, and effective (rms) voltage.	Have students draw a graph of the sine wave, labelling peak and RMS values.	RMS = Root Mean Squared Peak Voltage The maximum value that an AC voltage reaches during each half-cycle. Peak-to-Peak Voltage Twice the value of the peak voltage. Effective (RMS) Voltage The A.C. voltage required to do an equivalent amount of work of a DC voltage (RMS = 0.707 x peak voltage).
2. Calculate the effective (rms) voltage of a sine wave.	Demonstrate the use of the formula: $E_{RMS} = E_{Peak} \times 0.707$ Provide practice problems which require students to convert voltages from peak to RMS or peak-to-peak and vice versa.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
D. INDUCTORS IN AC CIRCUITS The student should be able to:		
1. Define inductor.	Review the relationship between electric current flow and resulting magnetic field. Point out that while even a simple straight wire is an inductor, the term is most often used to describe a coil of wire.	Inductor A coil of wire capable of generating a magnetic field around itself when a current passes through it.
2. State the unit of inductance and the letter which designates inductance.	Point out that the unit of inductance, the Henry, was chosen to honour Joseph Henry, an early scientist in the field of electricity.	Unit of Inductance The Henry (also, the millihenry and the microhenry) whose letter symbol is L.
3. Explain why a changing current is affected by an inductor, while a steady current is not.	Demonstrate by connecting a large iron core coil in series with a bulb. Connect to 6V AC, then 6V DC and ask students to note the difference in brightness. Discuss.	
4. Explain how inductors can develop a counter EMF.	Discuss self-inductance. Point out that there is a relationship between the moving magnetic field around the coil and the voltage developed across it.	Counter EMF An individual voltage developed across a coil and having a polarity opposite to the applied voltage.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
5. Explain inductive reactance.	Demonstrate inductive reactance. Point out that inductive reactance does not affect DC.	Inductive Reactance Opposition to current flow caused by inductance in an AC circuit.
6. List applications of inductive reactance.	Discuss circuits which use the concept of inductive reactance. Examples might include speaker crossover networks, dimmer circuits, etc.	
7. Explain the relationship between frequency of A.C. and inductive reactance.	Point out that as frequency increases, inductive reactance increases.	
8. Explain an example of mutual inductance.	Demonstrate an example of mutual inductance. Place two coils close together (preferably on the same core). When current is switched on and off in one coil, a voltage is induced in the second coil. Demonstrate with use of transformers.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
E. TRANSFORMERS The student should be able to:		
1. Explain the function and operation of a transformer.	Discuss the importance of transformers when a variety of voltages are required in modern appliances. Stress that transformers can be used to step up or step down current as well as voltage.	
2. Describe the construction of a transformer.	Discuss the basic construction of transformers. Identify coil names and show examples of a variety of transformers commonly found in radios, amplifers, etc. Discuss types of core construction styles and core materials.	
3. Explain the relationship among turns ratio, voltage ratio and current ratio.	Point out that the transformer turns ratio and the voltage ratio are always identical. Stress that this fact allows us to calculate unknown values of voltage or turns in a transformer primary.	Turns Ratio = $\frac{N_p}{N_s}$

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
4. Solve transformer problems involving turns ratios and power ratings.	Discuss and demonstrate the use of the following formulas: $\frac{N_p}{N_s} = \frac{E_p}{E_s} = \frac{I_s}{I_p}$ $P_{in} = P_{out}$	
5. Identify transformer losses.	Discuss types of losses which affect the efficiency of transformers.	
6. List applications of transformers.	Ask students to identify circuits which use transformers. Discuss.	Transformer Loses 1. Eddy Currents 2. Hysteresis 3. Copper Losses

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
F. CAPACITORS IN AC CIRCUITS The student should be able to:		
1. Define capacitive reactance.	Point out that the basic nature of a capacitor is to oppose changes in voltage. Remind students that in an AC circuit, voltage across a capacitor is constantly changing and thus an opposition to the current is developed by the capacitor. Demonstrate capacitors' reactance (Xc) by connecting a capacitor in series with a small bulb in a low voltage (6V AC) circuit.	Capacitive Reactance The opposition to AC caused by a capacitor.
2. Explain the relationship between AC frequency and capacitive reactance.	Discuss the factors which affect Xc. Stress the inverse relationship between frequency and capacitive reactance.	
3. Demonstrate that capacitors conduct alternating current but block direct current.	Demonstrate the effect that capacitors have on AC and DC. Use only low voltages (6 volts) for this demonstration.	

ACTIVE COMPONENTS - 101-06

Major Objective: To understand commonly used semiconductor devices.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. SEMICONDUCTOR AWARENESS The student should be able to:		
1. Define semiconductor.	Review the properties of conductors and insulators. Point out that the properties of semiconductors lie somewhere between those of conductors and insulators.	Semiconductor An electronic device that has been made from material which possesses some of the characteristics of both conductors and insulators.
2. List common semiconductor devices.		Common Semiconductor Devices 1. PN junction diode 2. LED 3. Zener diode 4. Bipolar transistors 5. SCR 6. IC
3. Explain the general function of common semiconductor devices.		

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
4. Draw and identify the proper schematic symbols for semiconductor devices.	Encourage students to pay particular attention to the arrows which are part of these semiconductor symbols.	Symbols to Know - PN junction - LED - Zener diode - Transistor
B. SEMICONDUCTOR CURRENT FLOW		
The student should be able to:		
1. Describe the difference between conventional current and electron current flow.	Discuss the definition of conventional current and electron current. Point out that the arrow in most semiconductor symbols represents the direction of flow of conventional current.	
2. Identify two basic types of bipolar transistors.	Discuss forward bias and reverse bias. Describe what happens when a diode junction is forward- or reverse-biased.	Basic Types of Bipolar Transistors 1. NPN 2. PNP
3. Explain how current flows through junction diodes, LEDs, and transistors.		

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
C. TESTING SEMICONDUCTORS The student should be able to:		
1. Use an ohmmeter to test diodes, LEDs, zener diodes, transistors.	Demonstrate appropriate use of an ohmmeter for testing semiconductors. Provide opportunities for students to practice testing semiconductors.	
2. Describe suitable replacement procedures for semiconductors.	Discuss the use of manuals for proper substitution of semiconductors.	Semiconductor substitution manual.
3. Demonstrate proper replacement procedures for semiconductors.	Demonstrate proper removal and installation procedures for semiconductors.	

POWER SUPPLIES - EE101-07

Major objective: To understand the operation of a variety of common solid state power supplies.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. A POWER SUPPLY		
The student should be able to:		
1. Identify safety procedures when working with power supplies.	Review general safety in the lab. Stress safe work habits regarding possible shock hazards when working on circuits.	Electronic Circuits, Heathkit
2. Identify the function of power supplies.	Point out that most of our electrical power comes in the form of 120V AC. However, modern solid state appliances run on low voltages in the range of 5-24V DC. It is the job of the power supply to convert to the appropriate level.	
3. List power-supply applications.	Show examples of power-supply circuits found in common appliances. Point out components in power-supply circuits and discuss their functions.	
4. List the basic parts of a typical transformer-type power supply.	Emphasize that transformer-type power supplies are used whenever the AC input voltage significantly varies from the intended DC output voltage.	Parts of a Transformer-Type Power Supply 1. Transformer 2. Rectifier circuit 3. Filter circuit 4. Regulator circuit

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
B. RECTIFICATION		
The student should be able to:		
1. Explain the process of rectification in circuits containing semiconductor diodes.	Explain how AC continously forward- and reverse-biases the diode(s). Show how this results in pulsating DC.	
2. Identify three types of rectifier circuits.	Discuss current flow in the three rectifier circuits.	Rectifier Circuit Types 1. Half-wave 2. Full-wave 3. Bridge
3. Draw schematics for and compare the operation of each of the three types of rectifier circuits.	Illustrate the manner in which the AC sine wave is processed in each rectifier circuit. Indicate the significance of the terms, half-wave and full-wave.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
C. FILTER CIRCUITS The student should be able to:		
1. Explain the purpose of filter circuits used in power supplies.	Discuss the need for very pure DC in modern electronic circuits. Point out that while diodes can change AC to pulsating DC, additional circuitry is needed to smooth out the DC.	
2. Define ripple.	Demonstrate the effect of poor filtration on the sound quality of an audio system, such as a radio or audio amplifier.	Ripple Voltage fluctuation in the output of a power supply.
3. Draw schematics of common filter circuits.	Demonstrate the use of the oscilloscope for showing power supply ripple.	
4. Describe the effect of filter circuits on the average output voltage of a power supply.	Point out that the DC output voltage of a power supply may appear to be higher than the AC voltage just before the rectifier diode(s). Explain that the AC voltage is "rms".	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
D. VOLTAGE REGULATOR CIRCUITS The student should be able to:		
1. Explain the need for voltage regulation.	Discuss voltage regulators. Point out that not all power supplies are designed to include voltage regulators. They are found in circuits which require precise control of voltage.	
2. Explain the function of a zener voltage regulator circuit.	Illustrate by drawing an actual circuit demonstration. Show how zener voltage regulators work. Stress that they are useful mainly in low current circuits.	
3. Identify an IC voltage regulator.	Point out that transistors and IC voltage regulators may have the same general appearance. The I.C. voltage regulator, however, will have a number stamped on it starting with 78__ . Make students aware that the IC voltage regulator is one of the most popular forms of regulator used today.	
4. Demonstrate proper connections of an IC voltage regulator in a circuit.	Provide an opportunity for students to experiment with I.C. voltage regulator circuits.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
E. DESIGNING AND TESTING POWER SUPPLIES The student should be able to:		
1. Demonstrate skill in the use of test instruments required for servicing solid state power supplies.	Review the use of tools, meters, and oscilloscope. Stress safety procedures while working on power-supply circuits.	
2. Develop a logical procedure to trouble-shoot a defective power supply.	Demonstrate proper procedures for troubleshooting power supply circuits. Encourage students to apply their knowledge of troubleshooting to actual power-supply circuits.	
3. Design a power supply.	Specify hypothetical power-supply requirements and then ask students to design a power-supply circuit to meet those conditions.	

AUDIO CIRCUITS - EE101-08 (Option)

Major Objective: To understand how electronic circuits can be used to amplify sounds.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. SOUND		
The student should be able to:		
1. Explain what sound is and how it is produced.	Discuss a variety of natural and electronic sources of sound. Point out several common electrical devices which produce sound. Discuss the method by which these devices are caused to vibrate.	Hobby Electronics, Heathkit Sound A series of air waves varying in pressure travelling from the source to the human ear.
2. Outline the process by which the human body "hears" sound.	Discuss the biology of the human ear. Emphasize the manner in which the ear converts vibrations into signals to be sent along the nervous system to the brain.	
B. AUDIO FREQUENCY		
The student should be able to:		
1. Define audio.	Ask students if there are "sounds" which humans can't hear. Establish reasons why we can't hear some sounds. Direct discussion to the range of frequencies humans can hear. Define audio and relate this to the discussion.	Audio Frequencies within the range of human hearing.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. State the range of audio frequencies which can beheard by the average person.	Use an audio signal generator to compare the hearing ranges of a number of individuals in the class.	Audio Frequency Range 20 Hz to 20,000 Hz.
3. List several electronic devices which produce or amplify audio frequencies.	Have students develop a list of all the appliances at home, school, and in the workplace which produce or amplify audio frequencies. Discuss.	
C. AUDIO SYSTEMS		
The student should be able to:		
1. Explain the basic process by which sound is converted to electrical energy and back to sound within an audio system.	Discuss methods of converting sound into electrical energy. Point out that the resulting electrical signal should have the same frequencies as the sound which produced it.	

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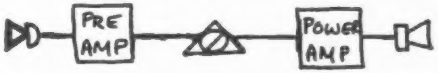
OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Draw a simple block diagram of an audio system and explain the basic function of each block.	Compare the block diagram to actual amplifier circuits. Point out the major blocks in actual circuits.	Audio System Block Diagram 
3. Select an appropriate audio system for home use.	Encourage students to develop a criteria for comparison of audio systems.	Sound Magazine Audio Today Magazine Consumers Reports Magazine
D. INPUT AND OUTPUT DEVICES		
The student should be able to:		
1. Define transducer.	Point out that transducers in electronic systems must produce an electrical signal capable of being processed by the circuit.	Transducer A device that can convert one form of energy into some other form (eg., microphone changes sound energy into electrical energy).

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Differentiate between crystal and electromagnetic methods of converting sound to electrical energy and vice versa.	Discuss microphone design and construction.	
3. Sketch the basic parts of common transducers.	If possible, provide students opportunities to see the actual components disassembled. Stress the delicate nature of most transducers.	Common Transducer Parts 1. Crystal microphone 2. Magnetic microphone 3. Speaker 4. Crystal earphone 5. Crystal and dynamic phono pickups 6. Magnetic tape head
E. SPEAKERS The student should be able to:		
1. Identify the basic parts of a permanent magnet speaker.	Discuss the importance of speakers in a well-designed audio system. Point out the basic parts of a permanent magnet speaker.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Define frequency response.	Obtain copies of frequency response curves for different speakers. Compare. Ask students to sketch a typical frequency response curve for an audio amp.	Frequency Response The rating of a device indicating its ability to operate over a specified range of frequencies.
3. Draw the frequency response curve for the "ideal" speaker.	Point out that particular attention should be paid to frequency response when purchasing speakers. Explain that frequency response curve for an "ideal" speaker should indicate a flat graph from 20 Hz to 20,000 Hz.	
4. Classify speakers into three categories according to their frequency response.	Discuss the need for three woofers, tweeters and mid-range speakers.	Types of speakers 1. Tweeter 2. Woofer 3. Mid-range
5. Explain what is meant by the impedance and wattage ratings of a speaker.	Discuss how speaker impedance is determined. Show speakers can be connected in series and parallel to match impedance.	Speaker Impedance The A.C. "resistance" of the voice coil at 1 kHz. Speaker Wattage A rating which indicates amount of sound energy or power the speaker can produce.
6. Demonstrate how to measure the size of a speaker.	Discuss the relationship between speaker size and frequency response, ie: the larger the speaker the better the low frequency response.	Speaker Size Determined by the measured diameter of the cone.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
7. Demonstrate how to test a speaker using an ohmmeter.	Review the term continuity. Discuss common speaker faults. (Emphasize that excessive current can cause overheating and burn out of wires in the voice coil.)	
8. Explain the function of a speaker crossover network.	Examine a crossover network and discuss the function of each part.	Crossover Network A circuit consisting of resistors, capacitors, and coils for dividing the audio frequencies into bands, such as bass, mid-range, and treble.
F. HEADPHONES		
The student should be able to:		
1. Identify the basic parts of light-weight headphones.	Point out the similiarities between permanent magnet speakers and modern lightweight headphones. Compare speaker and headphone voice coil, diaphragm (cone) and permanent magnet design.	Modern Lightweight Headphones Operate on the same principles as the permanent magnet speaker, and have the same basic parts.
2. Explain why stereo headphones need only three wire connections to the output of an amplifier.	Discuss the use of a common return wire. Explain that headphones often use one wire to deliver the signal to each of the headphones and a common return wire for both.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Demonstrate how to test headphones using an ohmmeter.	Remind students that since the earphones themselves are basically the same as speakers, they can be tested the same way. However, since the earphone wires may also be a source of problems, tests for shorts and opens should also be done on them.	
G. POWER AND VOLTAGE AMPLIFIERS The student should be able to:		
1. Explain the difference between a power amplifier and a voltage amplifier.	Discuss the need for the two different types of amplifiers. Point out that "head end" (or input) amplifiers are generally voltage amps, while output amplifiers are usually power amps.	Voltage Amplifier An amplifier used to increase the voltage level of an input signal while not greatly changing its current-delivering ability. Power Amplifier An amplifier that delivers a substantial amount of power (voltage and current) to the load.
2. Give an example of where a power amp might be used and where a voltage amp might be used.	Discuss power amps as output stages in audio amplifiers. Ask students to list a variety of common electronic systems using amplifiers. Make students aware of the use of pre-amps in audio circuits.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
H. BASIC AMPLIFIER CIRCUITS		
The student should be able to:		
1. Distinguish between DC and AC amplifier circuits.	Point out that although all transistor amplifiers require DC to operate, the intended purpose of an AC amplifier is to amplify an AC signal, while the DC amplifier is designed to provide an increase in direct current. Explain that DC amplifiers can be easily identified as they do not use capacitors, while AC amplifiers do contain capacitors.	
2. Recognize the schematic of a transistor amplifier circuit.	Discuss sample schematics.	
3. Demonstrate how to inject weak audio signals into an amplifier circuit and produce an amplified output signal.	Demonstrate the use of the audio-frequency generator. Provide students with an opportunity to develop skill in the use of the audio-frequency generator.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
I. AMPLIFIER CONTROLS The student should be able to:		
1. Identify components commonly found in volume control circuits.	Point out the volume control potentiometers in several amplifiers and/or radios. Emphasize the characteristic shape of a "pot" which makes it easily recognizable.	
2. Describe the function of basic volume controls.	Review the operation of variable resistors. Discuss the application of variable resistors in volume control circuits.	
3. Draw a circuit diagram which includes a simple volume control.	Have students identify volume controls on printed circuit boards.	
4. Explain the operation of a basic RC tone control.	Discuss the operation of the RC tone control circuits. Illustrate typical circuits and explain how high and low frequencies are controlled.	
5. Draw a circuit diagram which includes a simple RC tone control.		

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
J. SERVICE TECHNIQUES FOR AUDIO SYSTEMS		
The student should be able to:		
1. Perform basic troubleshooting operations.	Encourage students develop a systematic approach to locating basic problems common to audio systems. At this level, checks should focus on cables, connectors, fuses, power supplies.	
2. Clean noisy potentiometers.	Discuss symptoms of a potentiometer which needs cleaning. Demonstrate the use of a spray cleaning solution for potentiometers.	
3. Locate and rectify problems in cables and connectors.	Demonstrate continuity tests for audio cables and connectors. Provide opportunities for students to practice skills in basic service techniques for audio systems.	

RESIDENTIAL WIRING - EE101-09

Major Objectives: To understand basic concepts of residential wiring.
To understand the operation of residential wiring circuits.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. POWER DISTRIBUTION The student should be able to:		
1. Explain the electrical power distribution system from generation to residential user.	Discuss the production and distribution of AC power. Provide an illustration of the hydro-electric distribution system in Manitoba. Make students aware of the interconnection of hydro-electric grids throughout North America. Discuss DC hydroelectric power distribution systems.	References: Manitoba Hydro Posters Power Distribution System 1. Generator 2. High voltage transmission lines 3. Terminal stations 4. Substations 5. Distribution lines 6. Pole transformers 7. Service drop
2. Identify approximate voltage levels found in each stage of the electrical power distribution system.	Present a diagram showing typical voltage levels at various points in the power distribution system. Relate to local hydro substations, etc. Make students aware of the advantages of transmitting high voltage over long distances. Compare the normal household voltage, current and frequency used in North America to that of other regions around the world.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
B. SAFETY		
The student should be able to:		
1. Explain the purpose of residential grounding circuits.	Make students aware of the need for a grounding system in the home. Discuss common hazards which may result from faulty ground circuits.	
2. Identify ground pins on common electrical cords.	Provide a display of a variety of common plug ends. Point out the ground pin on three conductor cords.	
3. Explain the purpose of double-insulated tools.	Discuss the design of double-insulated tools. Stress the safety of their design which makes grounding unnecessary.	
4. Explain the purpose of plug polarization.	Explain the terms Hot and Neutral. Point out that many two-prong AC plugs are actually polarized because of one wide prong which prevents reversal of plug-in outlets. Discuss the danger in modifying or altering polarized plugs. Identify the "Hot" prong on a variety of polarized plug ends.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
5. List several safety rules pertaining to residential wiring.	Discuss general safe work habits and point out specific aspects of safety which relate to residential housewiring. Have students write out important rules.	
6. Repair three-conductor and two-conductor appliance cords.	Demonstrate how to repair two- and three-conductor appliance cords. Point out screw and wire colors which indicate hot, neutral, and ground wires. Provide an opportunity for students to practice repair of appliance cords.	
7. Explain the need for electrical wiring permits.	Encourage students to think of reasons why electrical wiring permits should be required. Stress invalidation of home insurance, risk of fire and personal injury, as well as difficulty in servicing later.	City of Winnipeg: Samples of Wiring Permits
8. Explain the need for electrical lock-out devices.	Define and discuss lock-out devices. Ask students to speculate on possible risks as a result of a failure to secure a lock-out device while working on a circuit.	Electrical Lock-Out Device Any mechanism which prevents power from being turned on in a circuit. Lock-out devices are important when residential wiring circuits are being worked on.

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OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
C. TOOLS/EQUIPMENT		
The student should be able to:		
1. Identify tools and equipment commonly used in residential wiring.	Demonstrate safe and correct use of common tools used in housewiring.	Common Tools and Equipment 1. Lineman's pliers 2. Neon tester 3. Wire stripper 4. Cable stripper 5. Fish tape 6. Drills & bits 7. Electrician's knife 8. Polarity tester 9. Hole saw 10. Wood chisel 11. Hack saw 12. Hammer 13. Measuring tools 14. Plumb bob 15. Crimping tool 16. Tool pouch 17. Side cutters 18. Screwdrivers 19. Saws 20. Conduit bender
2. Describe the proper care and use of common tools.	Discuss inspection and maintenance of common tools. Provide opportunities for students to develop skill in the use and maintenance of tools.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
D. CONDUCTORS/INSULATORS		
The student should be able to:		
1. Identify several types of wires and cables commonly used in residential wiring.	Provide a display of common wires and cables. Discuss the need for different types of wire for residential and commercial use. Compare size, flexibility, cost, etc.	Types of Wires & Cables 1. Non-metallic sheathed (NMS) cable 2. Metallic sheathed (armoured) cable 3. Conduit
2. Identify several types of insulation used in residential wiring.	Compare the insulation used on a variety of cables and wires. Discuss the need for a variety of insulation materials in housewiring.	Insulating Materials 1. NMD - Non-Metallic Dry 2. NMW - Non-Metallic Wet
3. Identify the characteristics and applications of several types of insulation materials.	Ask students to investigate the characteristics of insulation materials. Discuss their applications.	
4. List some factors which affect the selection of a conductor.	Discuss specific applications and the choice of appropriate wire. Ask students to predict effects of incorrectly selected wires.	Factors Affecting the Selection of a Conductor 1. Gauge size 2. Ampacity 3. Length 4. Resistance 5. Cold flow characteristics

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
5. Compare the characteristics of solid and stranded wire.	Demonstrate the greater flexibility of stranded wire. Also, compare the current carrying ability (ampacity) of stranded and solid wire. Discuss ease of installation.	
E. ELECTRICAL BLUEPRINT SYMBOLS The student should be able to:		
1. Explain how electrical wiring information is conveyed to the electrician at the construction or installation site.	Acquaint students with types of drawings used by electricians at the construction or installation site. Show examples of residential floorplans containing electrical layouts.	
2. Identify common electrical blueprint symbols.	Draw and discuss common electrical blueprint symbols. Have students draw the blueprint of a kitchen and label the parts.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
F. BOXES & RELATED HARDWARE		
The student should be able to:		
1. Identify common utility boxes used in housewiring.	Acquaint students with different types of utility boxes. Point out that each style of box has a particular application. Discuss box capacity for conductors.	Types of utility boxes 1. Octagon 2. Utility box & handy box 3. Rectangular box 4. Square box 5. Weatherproof box 6. Ganged boxes 7. Bakelite box 8. Service entrance panel (SEP) box
2. Explain the use and application of common utility boxes.	Discuss factors which affect the selection of boxes. Cite examples of wiring situations and ask students to select the appropriate box for each situation.	
3. Explain the use of hangars, covers, and recessed lighting fixtures.	Show examples of special hardware used in housewiring. Discuss applications.	
4. Use electrical code listings to determine the proper size and positioning of boxes and related hardware.	Emphasize that correct positioning of boxes includes height, rough-in depth, and distance between boxes, while size is determined by factors such as number of conductors and type of device(s) to be installed. Show how to use the code to determine size and positioning of boxes.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
5. Explain the need for a vapor barrier on exterior-surface boxes and enclosure devices.	Discuss the need for vapor barriers in modern home construction. Help students to understand the proper techniques for ensuring a good vapor barrier around electrial devices on exterior walls. Discuss modern alternatives to traditional vapor barrier seals.	
G. DEVICES		
The student should be able to:		
1. Identify common electrical devices.	Display common devices and discuss electrical connections on each. Compare a variety of styles of each device.	Common Electrical Devices 1. Switches 2. Receptacals 3. Lamp holders 4. Ground fault circuit interrupters (GFCI) 5. Fuses 6. Circuit breakers
2. Identify the uses for common electrical devices.	Discuss various situations in which different types of common electrical devices are used.	
3. Identify common lighting devices.	Provide a display of common lighting devices. Illustrate wiring of different types of devices. Discuss the operation of fluorescent lighting systems.	Common Lighting Devices 1. Incandescent lamps 2. Fluorescent lamps

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
4. Name several common low-voltage devices.	Discuss advantages of low-voltage wiring. Demonstrate several low-voltage devices in operation. Provide an opportunity for students to practice wiring a variety of low-voltage circuits.	Common Low-Voltage Devices 1. Transformers 2. Bells 3. Buzzers 4. Chimes 5. Thermostats 6. Magnetic switches 7. Smoke detectors 8. Relays
H. CONNECTORS & SPLICING DEVICES The student should be able to:		
1. Classify cable, clamp connectors and coupling devices according to use.	Make students aware that different types of cables require different types of connectors and couplers. Show examples and discuss their uses.	Classification of Connectors & Couplers According to Cable Type 1. Non-metallic sheathed(NMS) cable 2. Metallic sheathed(armored) cable 3. Conduit
2. Explain the need for anti-short bushings used with armored cable and conduit.	Illustrate the use of bushings for armoured cable and conduit. Stress the safety aspect of these devices.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Explain the need for common cable-anchoring systems.	Have students investigate the need for cable-anchoring devices. Discuss selection of the appropriate anchoring system.	Common Anchoring Systems 1. Staples 2. Straps 3. Tie wraps
4. Explain the proper placement of anchoring devices according to the Code.	Demonstrate the proper placement of anchoring devices. Refer students to the Electrical Code for proper distances from boxes and between anchors.	
5. Use appropriate solderless connectors to splice wires.	Show examples of different types and sizes of solderless connectors. Demonstrate their uses.	Solderless Connectors 1. Wire nuts 2. Crimp connectors
6. Choose appropriately sized solderless connectors for specific applications.	Emphasize that selection of improper size of solderless connectors may prevent secure contact or cause shorts.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
I. BASIC CIRCUITS		
The student should be able to:		
1. Draw wiring diagrams of common residential wiring circuits.	Ask students to prepare a wiring diagram for their own home. Encourage students to add to or make revisions in the wiring diagram to improve existing service.	Common Residential Wiring Circuits 1. SPST and 3-way switch circuits 2. Duplex outlets 3. Split duplex circuit 4. Split switched duplex outlet 5. Low-voltage bell/buzzer/chime circuits 6. Alarm circuits 7. Thermostat control circuits
2. Construct common residential wiring circuits.	Provide an opportunity for students to practice wiring common household circuits. Stress safety and good workmanship.	
J. SMALL AND MAJOR APPLIANCE CIRCUITS		
The student should be able to:		
1. Define small and major appliance circuits.	Discuss and have students define small and major appliance circuits.	Small Appliance Circuit 120 volt duplex circuit Large Appliance Circuit 240 volt circuit

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Identify common small and major appliances.	Ask students to make a list of small and large appliances found in their own homes. Discuss.	Small Appliances 1. Garburator 2. Dishwasher 3. Oil or gas furnace 4. Electric heaters 5. Washer 6. Freezer Major Appliances 1. Dryer 2. Hot water heater 3. Electric furnace 4. Oven/Range

CAREER EXPLORATIONS - EE101-10

Major Objectives: To understand the careers open to persons with some training in Electronics.
To investigate potential careers.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. CAREER CLASSIFICATION		
The student should be able to:		
1. Distinguish between occupations and careers.	Point out that occupations are jobs, while a career relates to one's advancement or progress in a vocation or occupation.	Choices (Computerized Career Information Retrieval Program)
2. Identify a variety of occupations related to the study of electricity/electronics.	Ask students to investigate several occupations in any of the following areas related to Electricity/Electronics: 1) Engineering and design, 2) Technical work, 3) Service Trades, 4) Broadcasting, 5) Construction, 6) Maintenance, 7) Sales, 8) Production and assembly.	Careers Manitoba Careers Canada
B. SKILLS & APTITUDES		
The student should be able to:		
1. Identify skills required for a particular occupation/career.	Have students select an occupation to research. Encourage them to discover the skills required for that job.	
2. Outline the training required.	Once skills have been identified for a particular job, ask students to investigate and discuss the training required. Also, identify where appropriate training can be obtained.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Discuss attitudes for achievement.	Ask students to develop a list of attitudes which might affect achievement in a career. Encourage discussion of both positive and negative attitudes.	
4. Predict the impact of technology on the career/occupation.	Have students speculate about the types of jobs which will become obsolete or more abundant due to changes in technology.	
C. JOB SEARCH TECHNIQUES		
The student should be able to:		
1. Identify major job advertisement sources.	Discuss sources of job listings to which students may have access.	
2. Interpret written job descriptions.	Develop criteria for gleaning important information from job descriptions.	
3. Demonstrate skill in writing resumes and preparing for job interviews.	Ask students to prepare a resume.	

PRINTED CIRCUITS - EE101-11

Major Objective: To become aware of the importance of printed circuits in modern electronic systems.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. PRINTED CIRCUITS BOARD(PCB) IDENTIFICATION		
The student should be able to:		
1. Locate and identify printed circuit boards in any electronic system which contains one.	Provide an opportunity for students to inspect a variety of printed circuit boards. Discuss the evaluation of industrial assembly techniques as a result of printed circuit development.	
B. ADVANTAGES OF PRINTED CIRCUITS		
The student should be able to:		
1. List several advantages of using modern printed circuits instead of hand-wired components.	Make students aware of advantages such as: 1) higher packaging densities 2) convenient base for mounting parts 3) more efficient soldering 4) interconnection of components 5) smaller and more sensitive parts	
2. Discuss the suitability of PCBs to automated and/or robotic assembly techniques.	Stress that only when sufficiently large numbers of PCBs are to be assembled does it become economical to automate mounting of parts.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
C. PCB CONSTRUCTION		
The student should be able to:		
1. Identify at least two materials used as bases for PCBs.	Compare epoxy and phenolic printed circuit board base materials. Ask students to distinguish between the two types.	
2. Outline the basic steps used in the construction of PCBs.	Discuss the industrial processes involved in making PCBs. Contrast industrial techniques to small-scale production of individual printed circuits. Stress the speed, efficiency, and material cost benefits of industrial mass production of PCBs.	
3. Design and produce a PCB.	Emphasize safety procedures.	
D. SOLDERING A PCB		
The student should be able to:		
1. Demonstrate skill in installing and soldering components into a PCB.	Provide an opportunity for students to solder components to PCBs. Stress self-evaluation of solder connections.	
2. Outline automated industrial techniques for soldering PCBs.	Point out that hand soldering is slow and not without some health risks. Discuss advantages of automated wave soldering, dip soldering and ultro-sonic soldering.	Mino/Micro Soldering and Wire Wrapping

☐ electricity/electronics 201 ☐

ELECTRICITY/ELECTRONICS 201

MODULE TITLE	CORE-C OPTION-O	PAGE
01 Student Orientation and Safety	C	113 - 115
02 Components	C	116 - 133
Minimum - Two of the following three: (C)		
03 Amplifiers	O	134 - 145
04 Electronic Circuits	O	146 - 157
05 Radio	O	158 - 167
Minimum - One of the following three: (C)		
06 OptoElectronics	O	168 - 173
07 Residential Wiring	O	174 - 185
08 Printed Circuits	O	186 - 190
09 Career Explorations	C	191 - 192

STUDENT ORIENTATION AND SAFETY - EE201-01

Major Objectives: To understand the structure of the 201 Electricity/Electronics course and method of evaluation.
To understand general shop safety and procedures.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. EXPECTATIONS AND EVALUATION		
The student should be able to:		
1. Summarize the general outline of the 201 Electricity/Electronics course.	Provide students with a course outline or overview. Discuss relative time allotments for units to be covered. Make students aware of the schedule and time allotment for labs vs lectures, films, etc.	
2. Summarize the method of evaluating students.	Discuss examination policy and evaluation procedure. Encourage students to keep accurate records of their marks.	
3. List expectations of behavior and personal deportment in the lab.	Discuss attendance policy. Outline procedure to be followed if absence occurs.	
4. Evaluate hypothetical behaviour in terms of acceptable standards for this course.		

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
B. ORGANIZATION OF LAB		
The student should be able to:		
1. Outline the layout of the lab.	Provide a tour of the lab with a general introduction to layout, placement of equipment and processes which take place in the lab.	
2. Identify purposes of tools, machines and equipment.	Give an orientation to acquaint students with the general processes which can be accomplished with specific tools and equipment in the lab.	
C. SAFETY AWARENESS		
The student should be able to:		
1. Understand the importance of safety.	Review the concept of safety awareness.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Identify hazards and danger areas.	List and discuss safety hazards which may be found in the lab.	
3. Recognize the need for appropriate apparel and protective devices in the lab.	Involve students in a discussion of the hazards relating to the wearing of inappropriate clothing in the lab. Point out the need for personal protective devices such as safety glasses, etc.	
4. Summarize general shop rules and housekeeping practices.	Discuss general shop procedures that are to be followed. Outline clean-up duties and procedures.	
5. Memorize emergency procedures.	Familiarize students with divisional safety procedures. Discuss emergency procedures in the event of fire and/or accident.	
6. Identify location of safety features in the lab.	Point out location and discuss use of: 1) fire extinguisher, 2) fire blanket, 3) first aid box, 4) panic button, 5) eye wash station, 6) goggles, 7) venting.	

COMPONENTS - EE201-02

Major Objective: To understand construction and application of the most common semiconductor diodes.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. PURE SEMICONDUCTORS		
The student should be able to:		
1. Name the commonly used semiconductor materials.	Familiarize students with the periodic table of the elements. Point out the location of germanium and silicon, which are the commonly used semiconductor materials. (Note: Carbon is also a semiconductor, but not typically used in the construction of semiconductor devices.)	SemiConductor Devices, Heathkit
2. Describe the characteristics of pure semiconductor materials.	Review characteristics of conductors and insulators. Discuss the unique characteristics of pure semiconductors.	Semi-Conductor Characteristics 1. Has a current-carrying ability somewhat better than an insulator, but somewhat less than a conductor. 2. Has four valence electrons. 3. Forms covalent bonding with other atoms.
3. Explain the bonding structure of semiconductor atoms.	Semiconductor atoms form very strong covalent bonds which result in ridgid crystals. Explain the process by which semiconductor atoms link up to form covalent bonding.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
B. DOPED SEMICONDUCTORS The student should be able to:		
1. Describe the process by which pure semiconductors are made into P-type and N-type materials.	Discuss the general process by which pure semiconductors are changed into P or N type semiconductor materials by the addition of impurity atoms.	Penta Valent Atoms which have 5 valence electrons. Tri Valent Atoms which have three valence electrons. Intrinsic Pure Doping The process of adding small amounts of impurity atoms to intrinsic semiconductor materials in order to change their characteristics.
2. Explain how current flows in intrinsic and doped semiconductors.	Make students aware of the action of majority carriers and minority carriers.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
C. DIODE CONSTRUCTION The student should be able to:		
1. Identify the different methods of diode construction.	Stress that diodes cannot be made simply by pressing P and N type materials together. List the three methods of diode construction. Point out that the most commonly used method is the diffused method.	Methods of Diode Construction 1. Grown Junction 2. Alloyed Junction 3. Diffused Junction
2. Describe the different methods of diode construction.	Compare three methods of diode construction.	
3. Compare the physical construction and applications of small diodes with those of power diodes.	Point out several diode applications. Stress that some diodes are used in high voltage, high current situations, while others will be used in only low voltage and/or current. The type of material used and the physical construction is determined by the voltage /current factors. Small signal diodes (sometimes called crystal diodes) are designed with low PIV rating (50 volts or less) and have relatively low current ratings (in the order of milliamps). Power diodes generally have PIV rating over 50 volts and may be rated at serveral amps or more.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
D. DIODE CHARACTERISTICS AND SPECIFICATIONS		
The student should be able to:		
1. Explain diode forward- and reverse-bias characteristics.	Compare forward- and reverse-bias characteristics ofsilicon and germanium. Have students graph the results.	
2. Explain the importance of diode current, temperature and PIV ratings.	Ask students to look up current, temperature, and PIV ratings for several diodes. Discuss the differences found.	
E. ZENER DIODE		
The student should be able to:		
1. Draw the schematic symbol for the zener diode.	Compare the zener symbol to the standard diode symbol.	
2. Describe the forward and reverse current-voltage characteristics of a typical zener diode.	Point out that while most diodes are normally forward-biased, the zener diode is usually reverse-biased. Emphasize that the zener is capable of going through reverse breakdown without suffering damage.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Describe how the zener diode is used to provide voltage regulation.	Review voltage regulation. Discuss the principles of zener voltage regulator circuits.	
4. Calculate the maximum safe operating current for any zener diode.	Make students aware that zeners, like other diodes, can be ruined by excessive current. Work sample problems calculating maximum zener current by using the formula: $I_{z\ max} = \frac{\text{Power Rating}}{\text{Zener Voltage}}$. Stress the importance of using maximum zener voltage in formula.	
5. Design a zener regulator circuit.	Provide an opportunity to construct a zener regulator circuit.	
6. Use a reference manual to look up "specs" on zeners.	Give students a zener diode number and ask them to look up "specs" in a reference manual. Discuss: 1) the zener voltage rating 2) maximum forward current 3) leakage current below breakdown	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
F. TRANSISTORS		
The student should be able to:		
1. Describe the basic physical construction of bipolar transistors.	Discuss the construction of bipolar transistors. Compare the construction of the transistor with that of the diode.	
2. Describe the operation of the bipolar transistors.	Discuss current flow through emitter, base and collector.	
3. Show how a bipolar transistor should be biased for normal operation.	Have students bias NPN and PNP transistor circuits for normal operation. Provide activities which allow construction and demonstration of operational transistor circuits.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
4. Explain the relationship among emitter current, base current, and collector current.	Discuss the relationships expressed by the formulas: $I_E = I_b + I_c$ $I_c = \bar{I}_b$	β = Beta
5. Explain the concept of transistor "gain" in terms of voltage amplification, and power amplification.	Define gain and discuss three types of gain in transistor circuits.	Gain The ratio of the output AC voltage to the input AC voltage. It may also be expressed in decibels.
6. Test bipolar transistors with an ohmmeter to determine if the devices have internal defects.	Demonstrate the ohmmeter method for testing bipolar transistors. Provide opportunities for students to practice testing transistors.	

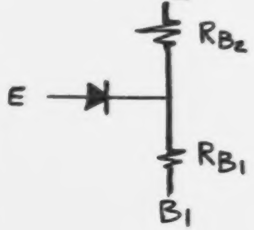
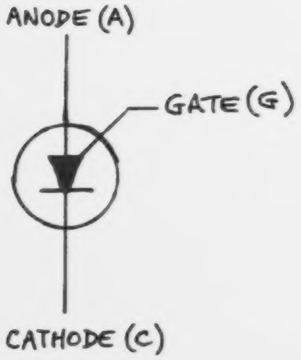
OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
G. FIELD EFFECT TRANSISTOR (FET) The student should be able to:		
1. Identify the purpose of the junction field effect transistor (JFET).	Point out that JFETs are capable of performing basically the same function as bipolar transistors. JFETs are used as amplifiers and switching devices.	
2. Describe how a JFET operates.	Stress that JFETs operate on an entirely different principle than bipolar transistors in that JFETs draw almost no gate current.	
3. Properly bias N-Channel and P-Channel JFETs.	Demonstrate and discuss proper biasing of JFETs.	
4. Explain the basic difference between the JFET and the MOSFET.	Present diagrams and have students sketch construction differences of JFETs and MOSFETs. Point out that MOSFETs are sometimes referred to as IGFETs.	MOFET Metal Oxide Semiconductor Field Effect Transistor IGFET Insulated Gate Field Effect Transistor

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
5. Name the three leads of a FET.	Draw FET symbols and have students identify leads.	FET Leads 1. Source 2. Drain 3. Gate
6. Compare the FET and the bipolar transistor operation.	Point out that while the bipolar transistor is a current-operated device, the FET is a voltage-operated device. Demonstrate how FET operation is similiar to vacuum tube operation.	
7. Compare the construction and operation of enhancement-type and the depletion-type FETs.	Discuss differences between enhancement-type and depletion-type FETS.	
H. SILICON CONTROLLED RECTIFIER (SCR)		
The student should be able to:		
1. Identify the purpose of an SCR.	Define the term thyristor and discuss several examples of thyristors. Point out that the SCR is one of the most widely used thyristors.	Thyristor A solid state component which is used as an electronically controlled switch.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
		Purpose of SCR To provide switching action to control electrical current.
2. Name two applications for the SCR.	Discuss application of SCR in light dimmers, motor control, color organ.	
3. Draw the standard electrical symbol for the SCR and identify the leads.	Point out the similiarity of the SCR symbol to a standard diode symbol. Have students identify cathode, anode, and gate leads on the symbol.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
4. Describe the conditions necessary to turn on or turn off an SCR.	Discuss the proper biasing of the SCR. Demonstrate the use of the SCR in phase control circuits. Provide an opportunity for students to build or experiment with circuits containing SCRs.	
5. Explain the difference between the SCR forward-breakover and reverse-breakdown voltage.	Compare SCR forward-breakover voltage and reverse-breakdown voltage to those of junction diodes.	Forward Breakover Voltage Voltage required to cause a forward-biased SCR to begin conducting when gate is open. Reverse Breakdown Voltage Reverse-bias voltage which causes the SCR to begin conducting. Same as PIV in normal diode.
6. Test an SCR to determine if it is defective.	Demonstrate SCR testing procedure. Provide an opportunity for students to practice testing SCRs.	
7. Design an SCR circuit.	Present a design problem where basic parameters are outlined and ask students to design a solution and draw the schematic.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
I. UNIJUNCTION TRANSISTOR (UJT)		
The student should be able to:		
1. Explain the operation of the UJT.	Point out that a UJT cannot amplify, but simply acts like an electronic switch. Contrast the operation of the UJT with the bipolar transistor.	
2. Draw the standard symbol for a UJT.	Illustrate and discuss the standard symbol for UJT.	
3. Describe two applications of the UJT.	Make students aware that since the UJT is a switching device, it is useful in generating repetetive signals. It is used in relaxation oscillators as well as in timing and control circuits.	
4. Name the three leads of the UJT.	Stress the that UJT is not capable of handling high currents and its output is generally used for triggering the gate of an SCR.	UJT Leads 1. Emitter 2. Base 1 3. Base 2

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
5. Compare the operation of the UJT and the FET.	Review the operation of the FET and ask students to compare to the operation of UJT.	
6. Describe the conditions required to "turn on" a UJT.	Draw and have students copy an equivalent circuit of a UJT. Discuss UJT operation in terms of an equivalent circuit.	UJT Symbol 
7. Compare a standard UJT and a programmed unijunction transistor (PUT).	Discuss the similarity between a PUT and a SCR.	PUT Symbol 
8. Identify the standard electrical symbol for the PUT.	Note the difference in location of the gate lead.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
J. DIAC The student should be able to:		
1. Describe the function of the Diac.	Point out that the Diac functions as a triggering device. Compare the Diac operation to two zener diodes connected back-to-back. Discuss its similarity to a voltage sensitive switch.	
2. Identify the most important application of the bidirectional trigger diode (Diac).	Discuss the operation of the Diac in its most frequent use as a triggering device for the gate of a Triac.	
3. Draw the standard electrical symbol for the Diac.	Draw and ask students to copy the symbol for Diac.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
K. BIDIRECTIONAL TRIODE THYRISTOR (Triac)		
The student should be able to:		
1. Describe the function of the Triac.	Point out that the Triac is ideal for use with A.C. circuits. Compare the Triac operation to SCR. Explain that Triacs act like two SCRs in parallel, but connected in opposite directions. Stress that even the appearance of the SCR and Triac is similiar.	
2. Identify two applications of a Triac.	Make students aware that Triacs are often found in household light dimmers and A.C. motor control circuits.	Film: "Now The Chips Are Down", Manitoba Education
3. Draw the standard electrical symbol for the Triac and identify the leads.	Draw and have students copy the triac symbol. Compare to SCR symbol.	Triac Leads 1. MT1 (Main Terminal #1) 2. MT2 (Main Terminal #2) 3. Gate
4. Describe the basic operation of a Triac.	Discuss the operation of a Triac using schematic drawings of typical circuits.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
5. Describe the conditions necessary to turn on or turn off a bidirectional triode thyristor (Triac)	Compare Triac biasing to SCR.	
L. INTEGRATED CIRCUIT (IC) The student should be able to:		
1. Define IC.	Outline the evolution of ICs from the 1960 to the present day. Discuss the definition of IC.	IC A thin semiconductor chip containing diodes, transistors, resistors, capacitors, and other semiconductor devices.
2. Describe the manufacture and construction of ICs.	Explain the process by which pure semiconductor materials are doped, solidified, sliced, etched, tested, diced, and then packaged.	
3. Identify common types of IC package styles.	Provide a display or illustration of common IC package styles. Encourage students to locate a variety of ICs within electronic appliances they use regularly.	IC Package Styles 1. Dual In Line (DIP) 2. Flat Pack 3. TO-5 4. TO-3 5. TO-220

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
4. List the advantages and disadvantages of ICs.	Point out that while ICs have many important advantages, there are also several disadvantages which make them inappropriate for use in some situations.	Advantages 1. Small and light 2. Consume very little power 3. Highly reliable 4. Inexpensive 5. Ideal for automated assembly of complex circuitry Disadvantages 1. Can be damaged by excessive heat 2. Limited voltage and current capacities 3. Cannot be repaired 4. Integrated resistors and capacitors require much space, thus their use must be limited 5. Inductors cannot be integrated
5. Explain the difference between linear and digital ICs.	Compare the operation of linear and digital circuits.	Linear ICs Used for amplifiers and regulators. Output signal is proportional to input signal. Digital ICs Switching devices used in logic devices and computers. Output is either "high" or "low".

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
6. List the applications of linear and digital ICs.	Discuss types of circuits which commonly use linear ICs. Compare these circuits with ones which are designed as digital systems.	
7. Use a technical manual to look up specifications of ICs.	Provide students with IC number and ask them to look up information re: 1) function or type of IC, 2) pin out, 3) operating voltage, 4) case style.	
8. Construct a working circuit using ICs.	Require students to breadboard or construct a permanent working circuit using at least one IC. Have students demonstrate the completed circuit and explain its operation.	

AMPLIFIERS - EE201-03

Major Objectives: To understand the general concepts of amplification in a variety of amplifier circuits.
To develop skill in troubleshooting faulty amp circuits.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. AMPLIFIER PRINCIPLES The student should be able to:		
1. Explain the concept of amplifier gain.	Make students aware that most types of electronic equipment have at least one stage of gain or amplification. Point out that most electrical signals require considerable amplification before sufficient strength is developed to drive output devices such as speakers, etc. Indicate that signal strength may be measured in terms of voltage, current or power.	Electronic Circuits, Heathkit Basic Electronics: A Text-Lab Manual, McGraw-Hill $\text{Gain} = \frac{\text{output signal}}{\text{input signal}}$
2. List the types of amplifier gain.	Make students aware that gain is commonly measured in three ways: 1) voltage, 2) current, 3) power.	
3. Calculate amplifier of voltage and current gain when appropriate information is given.	Provide the opportunity for students to calculate gain for a variety of amplifier circuits.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
4. Demonstrate the ability to measure the gain of an amplifier stage using the appropriate test instruments.	Show students how to take the appropriate measurements in order to determine the gain of an amplifier stage.	
5. List the types of transistor biasing methods.	Create an awareness of biasing methods commonly used in transistor amplifiers. Ask students to make comparisons between various biasing methods.	Biasing Methods 1. Base bias (fixed bias) 2. Feedback bias 3. Voltage divider bias
6. Compare several types of biasing methods used in transistor amp circuits.	Demonstrate or provide an opportunity for students to connect and observe the operation of properly biased transistor circuits.	
7. Distinguish between DC and AC transistor amplifiers.	Point out that transistors which act as AC amplifiers must have appropriate coupling between stages, generally capacitors. Explain that DC amplifier circuits never have capacitors or transformers connected in the signal path.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
8. Identify the types of transistor amplifier configurations.	Students should be able to identify the type of amplifier configuration by looking at the schematic of a circuit.	Transistor Amplifier Configurations 1. Common emitter 2. Common collector 3. Common base
9. Explain the operation of the common emitter amp.	Emphasize that the common emitter configuration is the most widely used, and thus should be well understood.	
10. Identify the amplifier classes of operation and compare each in terms of operation and efficiency.	List the classes of operation commonly used. Examine the operation of each class. Explain the differences in efficiency of the various classes of operation. Provide students with an understanding of "saturation" and "cut-off".	Amplifier Classes of Operation 1. Class A 2. Class B 3. Class AB 4. Class C 5. Other
11. Explain the process of amplification in an FET amp.	Review the operation of the field effect transistor. Diagram and have students discuss the operation of FET amp circuits.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
12. List the advantages of an FET amp over the bipolar transistor amp.	Point out that in many applications FETs can outperform bipolar transistors. Ask students to discuss situations where FETs might be preferable to bipolar transistors.	Advantages of FETs 1. Very high input impedance. 2. Low noise input. 3. Better linearity means less distortion. 4. Low interelectrode capacitance 16mm Film: "What's It All About?", BBC, Manitoba Education
13. Describe the function of the vacuum tube.	Briefly discuss the evolution of the vaccum tube. Have students compare different types of vacuum tubes. Ask students to make a comparison of semiconductor diodes and transistors to vacuum tubes.	
14. Explain the operation of diode and triode vacuum tubes.	Discuss the function of each of the electrodes inside diode and triode tubes. Have students speculate how each part of the tube relates to its overall function of amplification or rectification.	
15. Point out the similarities between the FET amp and the vacuum tube amp.	Have students compare the FET amp and the vacuum tube amp in order to point out similarities in design and operation.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
B. AMPLIFIER CIRCUIT COUPLING The student should be able to:		
1. Define coupling.	Point out coupling components in an amplifier schematic.	Coupling The means of transfering electronic signals from one stage to the next in an electronic circuit.
2. Explain the need for coupling amplifier stages.	Discuss the need for multi-stage amplifiers. Explain that sometimes one amplifier stage cannot provide enough gain. Thus, it becomes necessary to couple two or more amplifier stages together to achieve the required amplification. Point out the problem of blocking DC bias voltages while at the same time providing a path for the amplified AC signal to pass on to the following amplifier stage.	
3. List the methods of coupling amplifier stages.	Provide students with an understanding of each method of coupling.	Common Coupling Methods I. RC 2. Impedance 3. Transformer 4. Direct
4. Identify the advantages of each coupling method.	Stress the advantages and disadvantages of each method. Ask students to suggest applications where each type might be used.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
C. AMPLIFIER PERFORMANCE CHARACTERISTICS The student should be able to:		
1. Define frequency response.	Discuss the importance of frequency response. Point out that the "ideal" amplifier should perform equally well at all frequencies. However, in practice, this is never achieved. Therefore, we must be concerned about frequency response of any amplifier.	Frequency Response A comparison of gain to frequency, commonly expressed as a graph with amplifier gain on the vertical axis and frequency on the horizontal axis.
2. Explain how frequency response affects the overall performance of an amplifier.	Show an example of a frequency response curve.	
3. Explain the need for an overall "flat" frequency response curve in an amplifier.	Discuss the meaning of a "flat" frequency response curve. Ask students to investigate the importance of a relatively flat response curve.	
4. Identify factors which affect frequency response.	Point out that not all amplifier circuits are intended to have flat response curves.	Factors 1. Reactance of coupling circuits 2. Stray capacitance

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
D. FEEDBACK AMPLIFIERS The student should be able to:		
1. Define feedback.	Emphasize that feedback can be either positive (regenerative) or negative (degenerative).	Feedback A transfer of a portion of the output signal from a circuit back to the input.
2. Demonstrate how feedback can affect a typical amplifier circuit.	Have students arrange an amplifier system so that the microphone and speaker are close and facing each other. Discuss the resulting feedback. Point out that both gain and fidelity are affected by negative feedback.	
3. Identify potential sources of unwanted internal feedback in an amplifier circuit.	Briefly explain how stray capacitance and junction capacitance can introduce unwanted feedback in an amplifier.	
4. Explain how negative feedback can be used to extend the frequency response and gain.	Point out that with negative feedback, an amplifier provides somewhat lower but more uniform gain, which extends into higher frequencies.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
E. POWER AMPLIFIER FUNDAMENTALS The student should be able to:		
1. Describe the characteristics of a power amplifier.	Point out that a power amp not only amplifies voltage, but also amplifies current, providing an overall power gain.	
2. Compare the purpose and operation of voltage amplifiers and power amplifiers.	Review the importance of voltage amplification in an amplifier system. Stress that power amps must be capable of handling large voltage and current swings.	
3. Determine the power output of an amplifier stage.	Measure the voltage and current output of an amplifier stage. Show how this data can be used to determine power output of an amplifier. Discuss efficiency of an amplifier.	
4. List the advantages and disadvantages of push-pull amps.	Discuss the operation of a push-pull amplifier. Point out advantages and disadvantages of the push-pull operation. Ask students to make comparisons between push-pull and single-ended amps.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
5. Compare the operation of single-ended power amps and push-pull amps.		
6. Explain the need for heat sinks in high-power circuits.	Show examples of a variety of heat sinks. Point out some of the characteristics, such as surface area, texture, and material.	
7. Define thermal runaway.	Review the bonding structure of semiconductors. Describe the tendency of semiconductors to conduct more as their temperature rises. Explain that this in turn causes additional temperature rise. If this cycle continues thermal runaway results.	Thermal Runaway The buildup of heat within a transistor, causing excessive current flow. Permanent damage is often the result.
8. Explain how to prevent thermal runaway.	Illustrate the use of heat sinks in actual circuits. Explain that thermal runaway can be prevented by proper circuit design and heat-sinking semiconductors.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
F. TRANSFORMERLESS POWER AMPS The student should be able to:		
1. Explain the need for impedance-matching output transformers in tube-type amplifiers.	Review the term impedance and vacuum tube amplifier operation. Stress that output impedance of the tube is much greater than impedance of most speakers. Therefore, a matching transformer is required. Explain that vacuum tubes are very high output impedance devices which feed low-impendance speakers. Thus, impedance-matching is best accomplished with a transformer having a high-impedance primary and a low-impedance secondary.	
2. Compare the output impedence and current delivering ability of the transistor to that of the vacuum tube.	Point out that tubes and transistors have greatly differing impedance and current-delivering characteristics. Transistors tend to have very low output impedance and much higher current-delivering ability than vacuum tubes.	
3. List the advantages and disadvantages of using transformers in electronic circuits.	Discuss and ask students to weigh the advantages and disadvantages of transformers. Point out the obvious trend away from use of transformers in modern solid state circuits.	Advantages 1. Impedance-matching 2. Transformers can provide voltage or gain Disadvantages 1. Weight 2. Bulk 3. Cost 4. Poor frequency response

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
4. Compare the efficiency of a Class A single-ended transformerless amp with that of a Class B complementary symmetry transformerless amp.	Review Class A and Class B amplifier operation. Discuss the operation of a complementary symmetry transformerless amp. Stress the high efficiency of the Class B operation.	
5. Explain why a driver stage is generally needed when using a power amp output stage.	Discuss the base current requirements of power amps. Point out that amplifiers driving power amps must also be power amps, though they operate at much lower power levels.	
6. Explain the function of a phase inverter (or phase splitter).	Make students aware that phase inverters are driver stages that are sometimes called phase splitters. They develop two driving signals that are 180 degrees out of phase with one another.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
G. TROUBLESHOOTING AMP CIRCUITS		
The student should be able to:		
1. Identify hazards relevant to working with amplifier circuits.	Make students aware that because amplifiers are common to most electronic circuits, it is important to have a general understanding of how to troubleshoot them. Review general safety rules for electronics.	
2. Outline a general procedure for troubleshooting any amplifier circuit.	Assist students in developing a general approach to electronic troubleshooting. Stress the "divide and conquer" method of locating faulty circuits.	
3. Demonstrate skill in the use of appropriate instruments to locate and repair faults in amplifier circuits.	Provide activities which allow students to develop skill in the use of audio signal generator, oscilloscope, multimeters, etc.	
4. Practice safe procedures in working with amplifier circuits.	Monitor students' work habits in the lab to ensure that safety is maintained.	

ELECTRONIC CIRCUITS - EE201-04 (Option)

Major Objective: To become familiar with a variety of commonly used electronic circuits.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. AMPLIFIER CIRCUITS		
The student should be able to:		
1. Compare the function and operation of DC and AC amplifiers.	Point out that DC amplifers use a DC base current which is amplified to provide a larger DC output current. AC amplifiers require an input capacitor on the base to block any DC in the input signal.	Electronic Circuits, Heathkit
2. List the applications and characteristics of a variety of amplifiers.	Make students aware of circuits which incorporate various amplifier types. Have students investigate and compare characteristics of 1) audio amps, 2) video amps, 3) RF amps, 4) IF amps.	Circuits to be Familiar With 1. Audio amplifiers 2. video amplifiers 3. RF & IF amplifiers
3. List the applications of DC amplifiers.	Stress that while DC amplifiers can amplify low frequency AC signals, AC amplifiers can not amplify DC voltages.	
4. Identify the applications of A.C. amplifiers.	Ask students to list a variety of amplifier circuits. Focus on the diversity of circuit applications.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
B. POWER SUPPLY CIRCUITS The student should be able to:		
1. Name the three types of rectifier circuits and describe their operation.	Review the need for power supply circuits in modern electronic systems. Make sure students understand the process of rectification in half-wave and bridge circuits.	Rectifier Circuits 1. Half-wave 2. Full-wave 3. Bridge
2. List the advantages and disadvantages of each type of rectifier circuit.	Discuss reasons why one type of rectifier might be preferable to the others in a specific circuit.	
3. Determine peak and average voltage output from unfiltered rectifier circuits.	Demonstrate that a measured D.C. output from a power supply may appear less than the calculated peak output. Show how the average D.C. output can be determined in a filtered power supply circuit.	
4. Define ripple.	Examine the output voltage of a power supply using an oscilloscope. Discuss ripples. Increase the load on the output and have students observe the increase in ripple.	Ripple The AC component of power supply output voltage. It represents the amount of fluctuation of a DC voltage.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
5. Describe several methods of reducing ripple in power-supply output.	Ask students to suggest ways to reduce ripple in a heavy-load circuit. Discuss ways to improve the effectiveness of power-supply filter circuits to reduce ripple.	
6. Calculate percent ripple in a DC power supply output.	Demonstrate the use of the following formula to calculate percent ripple: $\% \text{ Ripple} = \frac{\text{RMS of Ripple}}{E_{AVG.}}$	
7. Define regulation.	Point out that the ideal power supply should have a constant output voltage. However, due to changing load resistance, and fluctuating input voltages, perfect (or "zero") regulation is nearly impossible to maintain.	Percent Regulation A ratio comparing the fluctuation of no-load and full-load voltage output in a power supply, commonly expressed as a percent.
8. Discuss need for voltage regulation in power supply circuits.	Stress importance with respect to linearity in amplifier circuits as well as for maintaining logic level references in digital circuits.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
9. Calculate percent regulation.	Use the following formula to demonstrate calculation of % regulation: $\% \text{ regulation} = \frac{E_{\text{NO-LOAD}} - E_{\text{FULL-LOAD}}}{E_{\text{FULL-LOAD}}} \times 100$	
10. Demonstrate the use of zener diode, transistor, and integrated circuit in voltage-regulator circuits.	Have students build a variety of voltage-regulator circuits which demonstrate the application of zener diodes, transistors, and IC voltage regulators. Compare the operation of each.	
11. Describe the purpose and application of voltage-multiplier circuits.	Draw and have students copy schematics of voltage doublers and voltage triplers. Discuss their operation and make students aware of several practical applications of voltage doublers.	
12. Explain the operation of a full-wave voltage doubler circuit.	Stress the advantages of full-wave doublers: 1) 120 Hertz ripple is easier to filter, and 2) smaller capacitors can be used.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
13. Explain the need for current overload protection in modern electronic equipment.	Discuss safety aspects, such as component overheating, fire and personal injury.	
14. Identify common current overload protection circuits.	Provide students with an understanding of common circuit overload protection devices, such as fuses, circuit breakers, and "crow bar" circuits.	
15. Demonstrate the ability to locate and repair common faults in defective power supplies.	Provide an opportunity for students to troubleshoot defective power-supply circuits. Ensure that students employ safe practices when working on circuits.	
C. OSCILLATORS		
The student should be able to:		
1. Define the term oscillator.	Make students aware that, as with amplifier circuits, oscillators are common to a vast number of electronic systems. Point out that oscillators are found in radios of all types, TVs, computers, electronic watches, and a wide variety of industrial controls.	Oscillator An amplifier with positive feedback. It produces an output, but requires no input signal to do so. Oscillators may be grouped into two categories: 1) continuous (sine wave), and 2) relaxation (non-sine wave).

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. List several oscillator applications.	Point out a variety of circuits which include oscillators. If schematics are available, show oscillator circuits therein. Explain that continuous wave oscillators are found in most communications systems, while relaxation oscillators are found mainly in computers and control systems.	
3. Discuss the effects of positive and negative feedback.	Stress the phase relationship between input and output signals. Emphasize that oscillation occurs when input and output are in phase (positive feedback). When input and output are 180 degrees out of phase, degenerative or negative feedback results.	
4. Summarize the characteristics of a good oscillator.	Emphasize the following characteristics: 1) amplification factor greater than one, 2) components must be capable of setting frequency of oscillation, 3) regenerative (in phase) output feedback to input, and 4) self starting.	
5. Compare the output wave shape of sine wave oscillators and relaxation oscillators.	Inform students that while sine wave oscillators are generally found in communication systems, relaxation oscillators are commonly found in computing and control systems. Output from relaxation oscillators tends to be pulses which achieve certain levels or amplitudes.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
6. Identify several common oscillator circuits.	Compare the operations of Hartley, Colpitts, Armstrong and Crystal oscillator circuits.	
7. Compare the operation of several oscillator circuits.	Provide an opportunity for students to experiment with several types of oscillator circuits.	
8. Discuss several methods of controlling undesirable oscillations.	Focus discussion on: 1) bypass capacitors, 2) proper layout of components and leads, 3) shielding, 4) neutralization by degenerative feedback.	
D. MODULATION/DEMODULATION CIRCUITS		
The student should be able to:		
1. Define the term modulation.	Discuss the importance of modulation in communication systems. Stress that in addition to audio signals, digital information can also be encoded on a carrier signal.	Modulation The process of encoding or superimposing information on a carrier signal.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Give several examples of circuits which use some form of modulation.	Ask students to list a variety of types of systems which might incorporate some form of modulation.	
3. Compare the characteristics of amplitude and frequency modulation.	Focus on differences between AM and FM in terms of: 1) way which modulation occurs in transmitter, 2) carrier wave shape and frequency, 3) type of detector used in receivers, 4) vulnerability to interference, 5) efficiency.	
4. Draw the basic block diagrams of modern AM and FM radio systems.	Draw and ask students to copy block diagrams of AM and FM transmitters as well as receivers. Point out that both AM and FM receivers are of the superhetrodyne type, with only small differences in receiver-block diagrams.	
5. Define detector.	Point out that a detector is sometimes called a demodulator.	Detector An electronic circuit capable of recovering information or intelligence from a modulated signal.
6. Explain the operation of AM and FM detector circuits.	Discuss and compare the operation of detectors in AM and FM receivers. Stress the rolesof the limiter and discriminator in FM.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
E. TUNED/RESONANT CIRCUITS The student should be able to:		
1. Define reactance.	Explain that in circuits containing inductors or capacitors, AC acts in a manner different from DC. This is because of the reactance presented by coils and capacitors. Compare reactance to resistance.	Reactance The opposition to the flow of alternating current in a capacitive or inductive circuit.
2. Explain the importance of reactance in electronic circuits.	Make students aware that since AC is so widely used in electronic circuits, it is vital to understand the manner in which reactance affects the operation of those circuits. Point out that reactance allows for selective passing or blocking of frequency bonds in a wide variety of circuits. Discuss types of circuit applications in which reactance plays an important role.	
3. Calculate inductive reactance (X_L) and capacitive reactance (X_C) using the appropriate formulas.	Provide an opportunity for students to practice skills in calculating reactance in inductive and capacitive circuits.	$X_C = 2\pi FL$ and $X_L = \frac{1}{2\pi FL}$

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
4. Apply Ohm's Law to reactive circuits.	Briefly review Ohm's law. Work sample problems showing how reactance values can be substituted directly into Ohm's law problems, replacing resistance factors. Ask students to work problems to calculate values of voltage, current and reactance using the formula: $E = I \times$ "X", where "X" = reactance in ohms. Typical problems might be: a) If $X = 10\Omega$ and $I = 2$ amps, $E = ?$ volts b) If $E = 100$v and $I = 1$ amp, $X = ?$ ohms c) Assuming $E = 9$v and $X = 270\Omega$, then $I = \underline{?}$ amps	
5. Explain how voltage-current phase relationship may change in reactive circuits.	Using purely reactive circuits, show how current and voltage are out of phase by 90 degrees. Point out that in RL and RC circuits, the phase angle is between 0 degrees and 90 degrees, depending on component values and frequency of AC. Stress that when reactors and resistance are equal in value, the phase angle is 45 degrees and the voltage drop across resistance and reactive device is equal.	
6. Determine voltage distribution and phase angle in series RC and series RL circuits.	Demonstrate the use of phasor diagrams to calculate the voltage distribution and phase angle in single series RL and series RC circuits.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
7. Define impedance.	Define and discuss impedance.	Impedance The total opposing effect offered by the resistance, capacitive reactance, and inductive reactance in a circuit.
8. Use the appropriate formula to determine impedance in reactive circuits.	Demonstrate the use of phasor diagrams in calculating impedance within RL and RC circuits. Compare results by using the formula: $Z = \sqrt{R^2 + X^2}$ Introduce RCL circuits and illustrate the use of phasor diagrams for these. Ask students to compare phasor diagram results to answers calculated by the formula $Z = \sqrt{R^2 + (x_L - x_C)^2}$. Stress that the expression "(X_L - X_C)" in the formula above simply denotes "the difference between X_L and X_C expressed in ohms".	Resonance The condition that exists when inductive reactance is equal to capacitive reactance in a circuit.
9. Define resonance.	Point out that when X_C and X_L are equal in a circuit, they cancel each other out. This is known as resonance.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
10. Explain the importance of resonance in electronic-circuits.	Show how the resonant effect can allow selective tuning or filtering of certain frequencies.	
11. Distinguish between series and parallel resonant circuits.	Briefly review series and parallel circuits. Discuss the operation of series and parallel resonant circuits. Ask students to demonstrate by experimentation or by verbal explanation the process by which selective tuning and filtering of certain frequencies is achieved.	
12. Explain what "Q" is and how it affects the bandwidth of a tuned circuit.	Discuss Q and show how it is calculated by the formula: $Q = \frac{X}{R}$ Use a frequency bandwidth graph to illustrate maximum current at resonance as well as the half-power points which determine the limits of the bandwith.	Q The ratio of the reactance (X) at resonance to the series resistance (R).
13. Calculate the "Q" of a resonant circuit.	Provide an opportunity for students to work practice problems.	

RADIO - EE201-05

Major Objectives: To become familiar with radio communication systems.
To understand the operation and servicing of modern superhet radio receivers.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. HISTORY OF RADIO		
The student should be able to:		
1. Briefly outline the early history of radio communications from the 1880's to the early 1990's.	Stress the contributions of Maxwell, Hertz, Edison, Marconi, and Fleming. Emphasize the importance of each person's contribution to the development of wireless communications.	The Sound and the Fury, An Anecdotal History of Canadian Broadcasting, Personal Library Understanding Communication Systems, Texas Instruments
2. Name the Canadian inventor of voice radio.	Discuss the contributions to the early development of radio made by the Canadian inventor, Reginald Fessenden.	
3. Outline the evolution of radio broadcasting in Canada from 1900 to the present.	Discuss the major inventions which led to the present technology in the field of commercial radio broadcasting in Canada. Discuss the events which led to the creation of the CBC.	
4. Name the inventor of the FM system of radio broadcasting and compare his system to AM.	Present a brief overview of FM and AM radio systems. Explain that Edwin Howard Armstrong, a U.S. citizen, invented FM radio in 1939. Limit discussion to a very general comparison of the two systems at this time.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
5. List several reasons why the superhetrodyne system has gained almost universal acceptance in modern radio broadcasting around the world.	Point out that the most widely used system of radio communication, the superhetrodyne, was introduced in 1927. Emphasize that a comparison to the other types of radio designs will come later in the unit.	Reasons (1) Ease of tuning and operation (2) Excellent stability and sensitivity (3) Simplicity of construction
B. RADIO FREQUENCY SPECTRUM		
The student should be able to:		
1. Identify a variety of forms of electromagnetic radiation.	Introduce the electromagnetic frequency spectrum. Represent by graph and locate a number of common forms of radiation such as: 1) electric waves (60 cycle current) 2) radio waves 3) infra red/visible light/ultraviolet light 4) x-rays 5) gamma rays	
2. Locate AM and FM radio frequencies on the electromagnetic frequency spectrum.	Show an expanded view of the radio wave portion of the spectrum and locate the frequencies allocated to AM and FM radio broadcasting.	AM = 535 KHz - 1605 KHz FM = 88-108 MHz

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Explain why radio transmitters are licensed to operate within a specific and limited frequency range.	Ask students to consider the possible effects of total lack of regulation of commercial broadcasting. Focus on frequency allocation, transmitter power, frequency drift, etc.	
C. EVOLUTION OF THE MODERN AM RADIO SYSTEM The student should be able to:		
1. Identify early types of receivers.	Review the early history of radio broadcasting. Present block diagrams of major AM receiver systems from the early crystal radio to the modern superhet. Stress the limitations which led to the evolution from crystal sets to TRF to superhet systems.	Early Types of Radio Receivers 1. Crystal receivers, used in the early 1900's. They consisted of a wire antenna, a tuning coil, a crystal detector (called a "cat's whisker") and a pair of earphones. 2. Tuned radio frequency (TRF) receivers, popular in the 1920's. TRF receivers consisted of several tuned radio frequency amplifiers using vacuum tubes. The output of the TRF was strong enough to drive a loudspeaker.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
		3. Superhetrodyne receivers are similar to TRF except that a variable frequency local oscillator, mixer, and IF amplifier are added.
2. Understand the general theory of operation of the different types of receivers.	Discuss the processing of radio signals by each radio system.	
3. Draw block diagrams showing the main parts of the basic types of receivers.	Present detailed block diagrams of crystal radio, TRF, and superhet receivers. Discuss the general operation of each block.	
4. Compare the terms, selectivity and sensitivity, as they apply to radio receivers.	Point out that radio systems must be sensitive enough to pull in weak distant signals and selective enough to separate or "select" one station from all the signals being transmitted.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
5. List the limitations of the crystal and TRF radios which led to the invention of the superhetrodyne system.	Review the evolution of radio technology. Emphasize the limitations of the crystal and TRF receivers.	Limitations of the Crystal Radio 1. Extremely poor sensitivity. 2. Poor selectivity. Limitations of TRF Receiver 1. Greatly improved selectivity and sensitivity but did not have uniform gain over its
6. Explain the operation of the AM transmitter.	Have students prepare a block diagram and explain the operation of a typical AM radio station transmitter.	
D. SUPERHETRODYNE CIRCUITS		
The student should be able to:		
1. Outline the theory of operation of the superhetrodyne radio.	Lead an in-depth investigation of the operation of the superhet radio receiver. Allow students to build or experiment with actual radio circuits. Students should be familiar with the following sub-circuits: - RF Amp - Mixer and Oscillator Stage - IF Amps - Detector Stage - Audio Stages - Automatic Gain Control (AGC)	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Calculate the frequencies found in each stage within the superhet radio.	Discuss signal processing within superhet. Ask students to select a radio station carrier frequency and then describe how each stage affects the signal shape, size or frequency. When given a station carrier frequency, the student should be able to calculate: - the operating frequency of the oscillator (Station frequency + kHz); - the output frequencies of the mixer stage (the station frequency, the oscillator frequency, the sum of station plus oscillator and the difference between station and oscillator).	
E. AM RADIO TROUBLESHOOTING The student should be able to:		
1. Identify the problems common within each stage of the AM superhet radio.	Provide students with a list of faults which commonly occur within each stage of the radio.	
2. Outline a logical procedure for troubleshooting an AM radio.	Review general procedures for troubleshooting electronic circuits by the "divide and conquer" method.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Demonstrate skill in the use of appropriate test instruments to repair faulty AM radio circuits.	Provide instruction and practice in the use of meters, RF and AF signal generators, oscilloscope, and signal tracers. Encourage students to build or repair radios to develop an understanding of the operation and troubleshooting of circuits.	
4. Demonstrate safe practices in the repair of radio circuitry.		
F. FM RADIO SYSTEMS		
The student should be able to:		
1. Identify the main circuits within an FM radio.	List the main circuits of an FM receiver.	
2. Draw the block diagram of an FM radio transmitter and receiver.	Present and have students copy a block diagram of an FM radio transmitter and receiver. Discuss the operation of each stage of the system. Stress the higher carrier, local oscillator, and IF frequencies. Explain that FM receivers are identical to AM, except FM includes a limiter stage to ensure uniform carrier amplitude and a discriminator circuit which detects the original modulation signal.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Compare the operation of and signal processing within FM and AM radio systems.	Discuss how each stage of the FM receiver processes the signal.	
4. Compare the advantages and disadvantages of FM and AM.	Point out that while AM and FM each have benefits and limitations, time has proven that each system continues to play an important role in commercial broadcast today.	
G. FM STEREO The student should be able to:		
1. Explain the process by which two FM signals are multiplesed into a single FM stereo broadcast signal.	Make students aware that FM stereo systems use an FM carrier which is modulated with two signals: one signal which is the sum of the left and right channel (L+R); while the other signal is the difference between left and right channels (L-R).	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Describe the process by which an FM radio receiver separates the stereo signal into two distinct channels of sound.	Point out that the signals are separated by converting the L-R signal into two AM sidebands which modulate the FM carrier. The L+R signal remains in the audio range (0-15 kHz). The L-R sideband signals are sent to an AM demodulator; the L+R signal is sent to a matrix circuit; and a third signal, 19kHz from transmitter, is doubled and set to the AM demodulator which produces two signals---(L-R) and +(L-R). By matrixing the (L+R), -(L-R) and +(L-R) signals, separate L and R stereo signals are recovered.	
H. FUTURE TRENDS IN RADIO		
The student should be able to:		
1. Predict some of the future trends in radio.	Ask students to collect current articles from popular electronics magazines and then make some predictions about the future of radio.	
2. Identify the potential uses for radio control in a variety of common appliances.	Have students prepare a report outlining potential uses for radio control of household appliances.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Discuss the advantages and disadvantages of single sideband radio systems.	Point out that single sideband (SSB) is a subclass of AM, consisting of one sideband and no carrier. Emphasize that while SSB is very efficient, it is also more expensive and requires much more critical tuning than AM.	

OPTOELECTRONICS - EE201-06

Major Objectives: To understand the operation and application of a number of electronic components capable of creating light or reacting to light.
To obtain a general understanding of fiber optic communication systems.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. LIGHT SOURCES & DISPLAYS The student should be able to:		
1. Discuss the characteristics of light.	Make students aware that OPTOElectronics is a portion of electronics which deals with the interaction of light with electronic circuitry. Emphasize the speed of light and range of wavelengths for the optical spectrum. Point out that the optical spectrum is divided into three regions: 1) infrared, 2) visible light, 3) ultraviolet.	Understanding Optronics, Texas Instruments
2. Define the optical spectrum.	Point out that coherent light is light which is "in phase". Optical waves act much the same as electrical signals. When optical waves have the same frequency and amplitude, but are out of phase, they interfere with one another and tend to cancel each other out. However, when the two beams are "in phase", they tend to produce a beam of light with twice the intensity. The ideal coherent light source produces a very pure single frequency light emission which results in extremely high energy levels.	Optical Spectrum A representation of a portion of the electromagnetic frequency sprectrum. Optical frequencies range from about 3 x 10^9 MHz to almost 3 x 10^9 MHz. Speed of light: 3 x 10^8 m/sec

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Describe the characteristics of coherent light.	Discuss the phase relationship of natural light. Point out that when light can be produced at a single frequency and amplitude and in phase (coherent), it can reach extremely high energy levels. Ask students to investigate methods of producing coherent light.	
4. Understand the advantages and disadvantages of light-wave communication systems.	Discuss the use of light as a carrier wave as opposed to lower frequency radio waves. Emphasize: 1) speed of travel through space 2) sensitivity to atmospheric interference and losses 3) bandwidth 4) power requirements	
5. Describe the construction and operation of light sources and displays.	Point out the common light sources and displays the student should be familiar with; i.e., glow discharge tubes, fluorescent and planar gas discharge tubes, seven segment LED, liquid crystal display, cathode ray tube and laser.	
6. Discuss the advantages and disadvantages of common display devices and light sources.	Encourage students to make comparisons between common display devices and light sources. Ask them to evaluate: 1) cost, 2) efficiency, 3) life expectancy, 4) serviceability, 5) size.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
B. LIGHT-REACTIVE DEVICES		
The student should be able to:		
1. Identify several light-reactive devices.	Prepare discussion of common light-reactive materials. Compare photo-resistive and photo-voltaic materials.	Common Light-Reactive Devices 1. Photo diodes 2. CdS cells 3. Phototransistors 4. PhotoFETs 5. LASCR 6. Phototubes 7. Opto-couplers
2. Draw standard electronic symbols for common light-reactive devices.	Introduce students to electrical symbols for: 1) Photo diodes 2) Cds cells 3) Phototransistors 4) PhotoFETs 5) LASCR 6) Phototubes 7) Opto-couplers	
3. Explain the principles of operation of the light-reactive devices.	Discuss the basic operation of the light-reactive devices listed above. Review applications of each.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
C. PHOTOVOLTAICS The student should be able to:		
1. Describe the construction and operation of the photovoltaic cell.	Review comparison between photo-resistive and photo-voltaic devices.	Solar Cells and Photo Cells, Howard W. Sams
2. Compare the voltage and current characteristics of photovoltaic cells.	Discuss the construction and operation of photovoltaic cells. Compare selenium cells to silicon cells in terms of output voltage and current ratings. Make students aware that while the life of photovoltaic cells is virtually unlimited, they are capable of only low power applications at the present.	
3. Discuss the future potential of photovoltaic devices.	Ask students to develop a report on the future of photo-voltaic devices.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
D. FIBER OPTICS The student should be able to:		
1. Outline the historical origins of lightwave communications.	Make students aware of the early photophone invented by Alexander Graham Bell in 1880. Discuss more recent developments which are major advancements in the field of lightwave communications: 1) Invention of the LASER (1960) 2) High efficiency LED (1962) 3) Semiconductor LASER (1962) 4) Development of LOW-LOSS silica glass fibers (late 1960's)	A Practical Introduction to Light Wave Communication, Howard W. Sams
2. List several applications of fiber optics.	Ask students to investigate applications of fiber optics and prepare a summary report.	
3. List the advantages and disadvantages of fiber-optic communication systems.	Compare fiber-optic communication systems with metallic-conductor communication systems. Discuss optical fiber advantages such as 1) low attenuation, 2) signal capacity, 3) security, 4) size and weight, 5) strength and flexibility, 6) immunity to interference. Point out optical fiber disadvantages such as 1) lack of current carrying ability, 2) high purity requirements, 3) repair difficulty, 4) deterioration if exposed to nuclear radiation.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
4. Name three basic parts of a fiber-optic communication system.	Draw a block diagram and discuss the function of each block in a fiber optic system: 1) transmitter 2) link 3) receiver	Basic Parts of a Fiber Optic Communication System 1. Optical transmitter (light source) 2. Optical receiver (light detector) 3. Optical link (eg. optical fiber or air)
5. Evaluate the future potential of fiber-optic systems.	Discuss future applications for fibre-optic systems. Ask students to speculate on possible future uses of fiber optics. Have students experiment with a variety of fiber-optic materials, such as heavy gauge fish line, plexiglass strips, glass rod and tubing, etc.	

RESIDENTIAL WIRING - EE201-07 (Option)

Major Objectives: To provide students with an in-depth study of residential wiring practices.
To enable the student to estimate costs involved in residential wiring jobs.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. REVIEW		
The student should be able to:		
1. Recall basic residential wiring safety procedures discussed in Electricity /Electronics 101.	Review safety procedures for residential wiring.	
2. Recall basic residential electrical symbols and circuit wiring practices presented in Electricity /Electronics 101.	Ask students to draw symbols for common housewiring devices.	
B. TOOLS AND EQUIPMENT		
The student should be able to:		
1. Describe the care and use of tools and equipment for residential wiring.	Discuss the inspection, maintenance, and use of residential wiring tools. Encourage students to be responsible for regular inspection of tools in the IA lab.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Explain the use of clamp-on meters.	Demonstrate the use of clamp-on meters. Discuss their advantages.	
3. Understand the use of conduit benders.	Explain and demonstrate procedures followed for bending conduits. Discuss the differences between handbenders and hydraulic benders.	
C. BLUEPRINT READING		
The student should be able to:		
1. Explain why electrical symbols and notations are used on electrical drawings.	Point out that symbols and circuit drawings are like a language through which we communicate a great deal of information. Stress the need for standard symbols and notations.	
2. Calculate the occupied floor area of a residential dwelling.	Discuss the importance of floor area of a dwelling when estimating electrical service required for a new home. Demonstrate how to calculate the occupied floor area.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Determine the total load requirements in amperes for general lighting in a dwelling.	Point out that lighting requirements are based on floor space in a dwelling. Work sample calculations and then ask students to do them. Explain that lighting standards call for 3 watts per square foot of floor space in a residence. $\text{Amperes} = \frac{\text{Watts}}{\text{Volts}}$	
4. Determine the number of lighting branch circuits required for a residential dwelling.	Provide a floor plan of a dwelling and ask students to establish the number of lighting branch circuits. Explain that branch circuits may include up to 12 lighting fixtures per circuit. Note: Lights need not be on separate circuits.	
5. Determine the number of small appliance branch circuits required.	Ask students to draw in duplex outlets on a floor plan. Explain that code requirements call for a maximum of 12 duplex receptacals per branch circuit.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
D. SERVICE ENTRANCE The student should be able to:		
1. Define service drop, service entrance, and underground service.	Define and discuss service entrance. Make students aware of underground and above-ground service entrances.	Service Drop Utility wires running from the last pole to the connection on the service entrance cable on the dwelling. Service Entrance All wiring and equipment from utility wire connections on the dwelling to the residential circuit breaker box inside. Underground Service Utility wires which deliver service to dwelling by means of a special buried cable.
2. Identify the basic parts of the service entrance.	Discuss parts required for the complete service entrance. Make students aware that meter sockets are not required for farm houses.	Basic Parts of Service Entrance (1) Mast kit (2) Meter socket (3) Service entrance panel (SEP) (4) Grounding system

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Describe proper placement of a SEP.	Provide examples of a number of site plans and ask students to discuss proper placement of a SEP.	Placement Factors of SEP 1. Location of utility connection 2. Location of major appliances 3. Minimum height above floor
4. Use electrical code book to determine conductor size for a service entrance drop.	Discuss conductor size required for 100-amp and 200-amp services. Ask students to look up wire size for a service entrance in the code book.	
5. Explain the grounding system used for a SEP and bonding of all service entrance equipment.	Point out that a SEP should be grounded to a water line or ground rod.	
6. Describe various types of fuses and circuit breakers.	Discuss the advantages of various protection devices.	
7. Explain the operation of fuses and circuit breakers.	Discuss and compare the operation of fuses and circuit breakers.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
8. Select the proper size fuse or circuit breaker for a particular installation.	Explain how the proper size circuit breaker is determined.	
E. DEVICES The student should be able to:		
1. Describe the construction and operation of common lighting devices.	Demonstrate the operation of a fluorescent light system. Discuss basic parts. Outline repair procedures. Have students wire a complete split switched outlet circuit.	Common Lighting Devices 1. Incandescent lamps 2. Fluorescent lamps 3. Mercury lamps
2. Understand the code requirements relating to the installation of surface mount and recessed lighting fixtures.	Have students study the code for installation of lighting fixtures. Stress the use of BX loom with glass over thermoplastic insultation.	
3. Explain the need for forced ventilation in residential dwellings.	Explain that forced ventilation is required to reduce excessive moisture, odour, or heat buildup in the home.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
4. Identify several areas in the home which may require forced ventilation.	Ask students to consider types of ventilating systems appropriate for attic, kitchen, or bathroom.	
5. Describe the types of forced ventilation devices commonly used in the home.	Identify and compare types of forced ventilation devices.	
6. Understand the operation of 4-way switches.	Draw a schematic of a 4-way switch circuit. Draw a wiring diagram of a 4-way switch circuit. Wire 3-way and 4-way switch circuits.	
7. List examples of where 4-way switches might be used.	Have students identify situations where 4-way switches might be used. Discuss the need for 4-way circuits in some hallways, outside entrances, stairways, etc.	
8. Explain the operation of low-voltage remote control systems for lighting.	Discuss the operation of low-voltage remote control lighting systems. Ask students to identify advantages of such a system.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
F. CONNECTORS AND SPLICING DEVICES.		
The student should be able to:		
1. Identify types of connectors and couplers used on a service entrance.	Ask students to wire a service entrance mock-up. Identify all service parts.	Types of Connectors/Couplers on Service Entrance (1) Screw type (2) Water-tight (3) Rigid (4) LB and TB type (5) LL and LR type
2. Identify types of connectors found on ground systems.	Show examples of a variety of connectors found on ground systems. Have students identify any they have in their own homes.	Types of Connectors on Ground Systems (1) Grounding bushings (2) Ground clamps (3) Ground rod (4) Split-bolt connectors
G. HEATING SYSTEMS		
The student should be able to:		
1. Identify types of residential electrical heating systems.	Compare the function of primary and secondary electrical heating systems. Wire up thermostats and a baseboard circuit.	Types of Electrical Heating Systems (1) Primary heating systems (2) Secondary heating systems

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Describe the types of primary heating systems commonly found in residential dwellings.	Have students investigate and prepare a report on the operation of baseboard heaters, radiant cables, and electric furnaces.	Primary Heating Systems (1) Baseboard heating (2) Radiant cables (3) Electric furnace
3. Explain the operation of secondary heating systems.	Create an awareness of the operation of secondary heating systems, such as baseboard heaters, radiant panels, and infrared heaters.	Secondary Heating Systems (1) Baseboard heaters (2) Radiant panels (3) Infrared heating
H. ESTIMATING COSTS		
The student should be able to:		
1. Determine the placement of electrical devices on a residential floor plan.	Require students to do an estimate of costs required in a complete wiring of their own homes.	16mm Film: "Basic Wiring", Manitoba Education
2. Determine the materials required to wire a complete residential dwelling.	Using a given dwelling, ask students to prepare a list of materials required to completely wire the structure.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Estimate the cost of materials required for complete wiring of a home.	Have students complete an estimate of cost of materials to wire a dwelling.	
4. Determine labor costs for wiring a residence.	Encourage students to contact local electrical contractors for information concerning labor costs.	
I. AC MOTORS The student should be able to:		
1. Name the various kinds of single-phase induction AC motors.	Discuss the various kinds of AC motors. Identify the basic AC motor parts. Show students samples where possible.	Single-Phase Induction AC Motors 1. Shaded Pole 2. Synchronous 3. Split Phase 4. Capacitor Start 5. Capacitor Start and Run 6. Two-Value Capacitor Start and Run 7. Repulsion Induction Other Single-Phase AC Motors 1. Repulsion 2. Universal

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Draw the schematic symbols for some of the AC motors.	Ask students to draw the various symbols. Point out the differences in the types of AC motors. Present some of the different types of AC motors. Discuss factors to consider when replacing electric motors, ie: horsepower, housing type, starting torque, etc.	
3. List several applications for the various single-phase AC motors.	Discuss the applications for several AC motors.	
4. Explain the need for the various starting arrangements in AC motors.	Stress the need for the assorted starting systems in the motors. Point out how the starting torque varies in the motors.	
5. Identify motor enemies and how to limit them.	Have students list the motor enemies and discuss how to minimize them.	Motor Enemies 1. Water 2. Dust 3. Friction 4. Vibration 5. Overload 6. Underload 7. Misalignment 8. Improper Lubrication

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
6. Identify the types of motor housings.	Show students the types of enclosures.	Types of Housings 1. Open (Drip Proof) 2. Splash Proof 3. Dust Proof 4. Explosion Proof
7. Explain the basic difference between single-phase and three-phase motors.	Point out that single-phase motors produce a pulsating magnetic field while three-phase motors produce a rotating magnetic field.	
8. List the two types of three-phase motors.	Discuss three phase motor rotors: wound and squirrel cage.	
9. Explain the function of an automatic motor starter.	Discuss the operation of a magnetic (electro-magnetic) motor-starter unit.	

PRINTED CIRCUITS - EE201-08 (Option)

Major Objectives: To understand the materials and processes involved in industrial manufacturing of printed circuit boards.
To develop the student's ability to construct and repair PCBs.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. TYPES OF PRINTED CIRCUIT BOARD (PCB) MATERIALS The student should be able to:		
1. Define laminate, cladding, artwork, resist, and etchant.	Discuss the raw materials required for design and manufacture of modern printed circuit boards in industry. Provide examples. Point out that there are three types of PCB: 1) single-sided, 2) double-sided, 3) layered. Show examples of single- and double-sided PCB's.	Printed Circuit Boards, Heathkit Laminate The base material (substrate) of a printed circuit board commonly made of phenolic paper, epoxy glass, or epoxy paper. Cladding The metallic foil layer that is bonded to the substrate and becomes the conductive pattern after etching. Artwork The master pattern, or layout, to be etched to form the circuit pattern. Resist A material that is resistant to the etching acid used in making printed circuit boards.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
		Etchant The acid solution that attacks and removes selected portions of printed circuit cladding.
2. Identify the types of laminate materials commonly used in PCB manufacture.	Discuss characteristics of laminate materials.	Types of Laminates (1) Phenolic paper (2) Epoxy paper (3) Epoxy glass
3. Describe several factors which influence the choice of PCB laminate material.	Point out that choice of PCB laminate depends on exposure to: 1) heat 2) mechanical stress 3) flexing 4) weight of components	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
B. DESIGN & MANUFACTURING PROCESSES The student should be able to:		
1. Prepare an outline of the procedure used in large scale industrial manufacturing of PCBs.	Stress preparation steps as well as actual manufacture of boards. These include: 1) Design of circuit 2) Artwork layout and photographic preparation 3) Surface cleaning of cladding 4) Resist application 5) Exposure 6) Etching 7) Resist removal 8) Inspection	
2. Design an original PCB to be used in a functional electronic circuit.	Ask students to design a PCB from a schematic diagram provided. Stress efficient layout, placement of parts, ease of assembly, spacing of pads and tracks.	
3. Compare the silk-screen method and the photo-etch method of PCB production.	Provide an illustration, film, or demonstration of silk-screen and photo-etch methods of PCB production. Stress that the silk-screen method is satisfactory where fine detail and definition are not critical. The photo-etch method, however, is more widely used in large-scale industrial manufacturing.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
C. PCB ETCHING AND ASSEMBLY The student should be able to:		
1. Outline the etching process and necessary safety procedures to be followed during this phase of PCB construction.	Briefly discuss the chemical reaction which causes the copper to be removed from the PCB. Point out that ferric chloride is the most commonly used etchant. Stress the danger to eyes, skin, clothes etc. Discuss the need for proper containment, ventilation, and disposal of etchant.	
2. Describe the steps which the etched PCB must go through in preparation for parts mounting.	Make students aware that after etching, the PCB must be thoroughly rinsed to remove all traces of etchant. Outline additional procedures which may be involved in preparation for parts mounting: 1) cutting or punching (ie: holes and special shapes) 2) drilling 3) deburring 4) inspection	
3. Outline some precautions regarding proper component mounting on PCB.	Point out that heat dissipation and current requirements of some components may demand special spacing and mounting requirements. Consideration must also be given to axial vs radial leads.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
4. Demonstrate the ability to etch and assemble a PCB project.	Provide an opportunity for students to etch a PCB of their own design. Ask that a completed project be assembled and demonstrated upon completion.	
5. Demonstrate skill in repair of damaged PCBs.	Encourage students to practice repair of damaged PCBs. Note that repair of a PCB means locating and rectifying cracked or shorted traces, lifted pads, etc.	

CAREER EXPLORATIONS - EE201-09

Major Objectives: To provide the student with an understanding of the careers open to persons with some training in Electronics.
To investigate potential careers.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. CAREER CLASSIFICATION		
The student should be able to:		
1. Distinguish between occupations and careers.	Point out that occupations are jobs, while a career relates to one's advancement or progress in a vocation or occupation.	Choices (Computerized Career Information Retrieval Program), Canada Systems Group
2. Identify a variety of occupations related to the study of electricity/electronics.	Ask students to investigate several occupations in any of the following areas related to Electricity/ Electronics: 1) Engineering and design, 2) Technical work, 3) Service Trades, 4) Broadcasting, 5) Construction, 6) Maintenance, 7) Sales, 8) Production and assembly.	Careers Manitoba Careers Canada
B. SKILLS & APTITUDES		
The student should be able to:		
1. Identify skills required for a particular occupation/career.	Have students select an occupation to research. Encourage them to discover the skills required for that job.	
2. Outline the training required.	Once skills have been identified for a particular job, ask students to investigate and discuss the training required. Also, identify where appropriate training can be obtained.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Discuss attitudes for achievement.	Ask students to develop a list of attitudes which might affect achievement in a career. Encourage discussion of both positive and negative attitudes.	
4. Predict the impact of technology on the career/occupation.	Have students speculate about the types of jobs which will become obsolete or more abundant due to changes in technology.	
C. JOB SEARCH TECHNIQUES		
The student should be able to:		
1. Identify major job advertisement sources.	Discuss sources of job listings to which students may have access.	
2. Interpret written job descriptions.	Develop criteria for gleaning important information from job descriptions.	
3. Demonstrate skill in writing resumes and preparing for job interviews.	Ask students to prepare a resume.	

electricity/electronics 301

ELECTRICITY/ELECTRONICS 301

MODULE TITLE	CORE-C OPTION-O	PAGE
01 Student Orientation and Safety	C	195 - 197
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04 Electronic Communication Systems	0	208 - 214
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06 Digital Concepts & Microprocessors	0	229 - 243
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08 Robotics/Interfacing	0	252 - 257
09 Residential Wiring	0	258 - 269
10 Career Explorations	0	270 - 272

STUDENT ORIENTATION AND SAFETY - EE301-01

Major Objectives: To understand the structure of the 301 Electricity/Electronics course and method of evaluation
To understand general shop safety and procedures.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. EXPECTATIONS AND EVALUATION		
The student should be able to:		
1. Summarize the general outline of the Electricity/Electronics 301 course.	Provide students with a course outline or overview. Discuss relative time allotments. Inform students of exam schedule and lab schedule.	
2. Summarize the method of evaluating students.	Discuss examination policy and evaluation procedures. Encourage students to keep accurate records of their progress.	
3. List expectations of behavior and personal deportment in the lab.	Discuss attendance policy. Outline procedure to be followed in the event of absence.	
4. Evaluate hypothetical behaviour in terms of acceptable standards of behavior.	Describe hypothetical classroom situations and ask students to discuss acceptable standards of behavior.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
B. ORGANIZATION OF LAB		
The student should be able to:		
1. Outline the layout of the lab.	Provide a tour of the lab. Present a general introduction to layout, placement of equipment and processes which take place in the lab.	
2. Identify purposes of tools, machines and equipment.	Orientate students to the general processes which can be accomplished with specific tools and equipment in the lab.	
C. SAFETY AWARENESS		
The student should be able to:		
1. Understand the importance of safety.	Review safety expectations. Ask students to discuss the term, safety consciousness.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Identify hazards and danger areas.	List and discuss safety hazards which may be found in the lab.	
3. Recognize the need for appropriate apparel and protective devices in the lab.	Involve students in discussion of hazards relating to the wearing of inappropriate clothing in the lab. Point out the need for personal protective devices such as safety glasses, etc.	
4. Summarize general shop rules and housekeeping practices.	Discuss the general shop procedures that are to be followed. Outline clean-up duties and procedures.	
5. Memorize emergency procedures.	Familiarize students with divisional safety procedures. Discuss emergency procedures in the event of fire and/or accident.	
6. Identify location of safety features in the lab.	Point out the location and discuss the use of: - fire extinguishers - fire blanket - panic button - first aid box - eye wash station - goggles - venting	

COMPONENTS - EE301-02

Major Objectives: Understand the function and operation of a variety of linear and digital ICs.
Become familiar with the common use of piezoelectric crystals.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. INTEGRATED CIRCUITS The student should be able to:		
1. Classify integrated circuits according to construction, operating mode, and packaging.	Explain that integrated circuits may be classified in a variety of ways. Discuss IC classification by methods of construction, operating mode and packaging.	*Concepts of Electronics*, Heathkit *SemiConductor Devices*, Heathkit Methods of Construction 1. monolithic 2. hybrid (thin film, thick film, etc.) IC Operating Modes 1. Analog (or linear) 2. Digital (or logic) IC Packaging Styles 1. Dual Inline Package (DIP) 2. TO-5 Style 3. Flat Pack
2. Compare the characteristics of TTL and CMOS ICs.	Discuss the construction and operational differences between TTL and CMOS. Stress the importance of special care in the handling of CMOS ICs.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Be familiar with the operation of the following linear ICs: - 741 op amp, - 555 timer, - LM386 audio amp.	Provide an opportunity for students to construct and demonstrate the operation of circuits using the 741, 555, and LM386 ICs.	
4. Demonstrate the operation of common digital logic gate ICs.	Review the operation of digital circuits (201, Mod. III). Introduce the common logic gates: AND, OR, NOT, BUFFER, NAND, NOR. Explain the operation of each of the logic gates. Explain that 7400 Quad NAND gate ICs can be used individually or in combination to make the other digital logic gates: AND, OR, NOT, NOR, BUFFER. Provide students with an opportunity to construct and explain the operation of common logic gates using digital ICs.	
5. Summarize the operation of digital IC memory circuits.	Define the term, memory circuit. Make students aware that complex electronic memory circuits are made up of many simple flip-flops. Explain that flip-flops, individually or in combination, form the basic digital memory circuit. The 7400 digital IC can be used to construct a flip-flop memory circuit.	Memory Circuit A circuit that can "store" or remember digital information which is input. The output of a memory circuit depends on a sequence of inputs. The most basic digital memory circuit is the flip-flop.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
B CRYSTALS		
The student should be able to:		
1. Define piezoelectric effect.	Define and discuss the piezoelectric effect. Point out that some crystals which occur in nature exhibit the piezoelectric effect.	Piezoelectric Effect A vibration of a crystal when an A.C. voltage is applied.
2. Name the crystal materials which demonstrate the piezoelectric effect.	Emphasize that only a few materials are capable of producing electricity by the piezoelectric effect. List examples of crystals which show this relationship between electrical and mechanical effects. Explain that the piezoelectric effect is observed in quartz rochelle salts, and tourmaline. Rochelle salts exhibit the most physical movement or vibration; however, they are the weakest. Tourmaline has the least piezoelectric activity and has the is the most expensive, but it is also the strongest. Quartz is the most often used crystal since it is a compromise of strength and piezoelectric activity.	
3. List several types of circuits which commonly use piezoelectric crystals.	Discuss the design and operation of a variety of devices using piezoelectric crystals. Stress the simplicity and inexpensiveness of many of these devices.	Circuits which Use the Piezoelectric Effect 1. Microphones 2. Phono pickups 3. Earphones 4. Radio transmitters 5. Radio receivers

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
4. Draw the standard electrical symbol for a crystal.	Point out that the word "crystal" is often abbreviated "XTAL" on schematics. Ask students to identify crystals found in actual circuit schematics.	
5. State the advantages of using crystals in oscillators.	Make students aware that most oscillators must operate within very close tolerances of frequency through a wide range of temperatures and environmental conditions. The crystal oscillator is ideally suited to such applications.	Advantage of Crystal Oscillators 1. Extreme precision of frequency 2. Very stable (extremely small frequency drift)
6. Explain how the cut of a crystal affects the natural frequency.	Discuss how the physical dimensions of crystal affect the frequency of crystal. Point out that the thinner the cut of the crystal, the higher the natural or resonant frequency.	
7. Define crystal fundamental frequency and overtones.	Point out that when the AC applied to a crystal exactly matches, or is an exact multiple of its natural frequency, the crystal will begin to vibrate.	Fundamental Frequency The lowest resonant frequency of a crystal. Overtones The higher resonant frequencies of a crystal (exact multiples of the fundamental frequency).
8. Compare several types of crystal oscillator circuits.	Review the operation of the Hartley and Colpitts Oscillators. Compare the operation of the Hartley crystal oscillator and the Colpitts crystal oscillator.	

ELECTRONIC CIRCUITS - EE301-03

Major Objectives: To become familiar with the operation of the op amp circuits.
To learn how non-sine wave circuits can be useful.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. INTEGRATED CIRCUITS OP AMPS The student should be able to:		
1. Draw the standard symbol for the op amp and correctly label the input and output terminals.	Point out that "op amp" is short for operational amplifier. Have students draw and label the symbol for an op amp.	Electronic Circuits, Heathkit Electronic Principles & Applications, McGraw- Hill
2. List the characteristics of the ideal op amp.	Discuss op amp characteristics. Stress that its characteristics make it one of the most versatile electronic circuits used today.	Characteristics of OP Amp 1. Very high gain 2. Very high input impedance 3. Very low output impedance 4. Infinite bandwidth
3. List several practical applications of the op amp.	Make students aware that op amps can be used as comparitors, inverting amplifiers, noninverting amplifiers, and voltage followers. Point out that the 741 op amp is one of the most common op amp ICs. Provide examples of circuits which contain an op amp IC.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
4. Illustrate the basic circuits inside the op amp by drawing a block diagram.	Make students aware that inside an op amp, there are three different amplifiers, each with its own unique characteristic. Point out that the op amp requires a bipolar power supply.	
5. Identify three basic op amp circuit configurations.	Remind students that the op amp, like the transistor and FET, has three basic circuit configurations.	Basic OP Amp Configurations 1. Inverting amplifier 2. Non-inverting amplifier 3. Voltage follower
6. Calculate the voltage gain of op amp circuits.	Discuss the effects of the input resistor and the feedback resistor on the overall gain of the op amp. Emphasize that different formulas are used to calculate gain of op amp configurations. Ask students to draw a schematic of a voltage follower and then have them demonstrate by calculation why the gain always equals 1 for this configuration.	Gain (Inverting Op Amp) = $A_r = \frac{R(Feedback)}{R(Input)}$ Gain (Non-Inverting and Voltage Follower) = $A_r = 1 + \frac{R(Feedback)}{R(Input)}$
7. Construct several simple inverting and non-inverting amps using op amps.	Provide an opportunity for students to construct op amp circuits. Ask them to calculate and then measure the gain of those circuits.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
8. Describe how op amps can be used to construct active filters.	Review the operation of RC and LC filter circuits. Define "active filter" as an RC filter used with one or more op amps to provide improved signal output at certain frequencies.	
9. Demonstrate how op amps can be used as ramp generators.	Define the term, ramp. Discuss types of ramp wave forms: sawtooth, arapazoid and triangle. Draw and explain the action of a feedback capacitor in an op amp circuit.	Ramp That part of a wave form that changes linearly with time.
B. PULSE CIRCUITS The student should be able to:		
1. Define and draw periodic waveforms, sinusoidal waveforms, and pulse waveforms.	Identify the characteristics of periodic waveforms. Make students aware that pulse waveforms are made up of sine waves.	Periodic Waveform A waveform which repeats itself at definite time intervals. Sinusoidal Waveform A wave form having the shape of a sine wave. Sinusoidal waves can be added together to form any type of periodic waveform. Pulse Waveform Any non-sinusoidal waveform.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. List pulse circuit applications.	Point out that pulse circuits are used in test equipment, television, computers, and radar.	
3. Demonstrate how the appropriate combination of sine waves can result in square waves, sawtooth waves, or other complex waveforms.	Discuss the relationship between sine waves, square waves and sawtooth waves. Show students how combinations of the right sine wave harmonies can result in complex pulse waveforms.	
4. Demonstrate how diodes and transistors can produce a variety of clipping effects on waveforms.	Review with students the need to change the shape of a waveform in some circuits. Explain that clipper circuits (sometimes called limiters) act to limit the maximum voltage of a circuit. Clippers are used for wave shaping and for protecting circuits against extreme voltage variations.	
5. Demonstrate how diode clamper circuits can be used to change the DC reference voltage of a waveform.	Point out that unlike clipper circuits, clampers do not change the shape of the original waveform, but simply insert a DC reference voltage. Explain that clamping circuits are used to add a DC reference voltage to a waveform, by the action of a capacitor working in conjunction with a diode in the clamping circuit.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
6. Explain why clamper circuits are sometimes called DC restorer circuits.	Acquaint students with the use of clamper (DC restorer) circuits at the cathode of a television picture tube. Emphasize that clamper circuits "shift" AC signals so that they become ground referenced DC waveforms having the identical shape of the original signal.	
7. Describe the characteristics of multivibrator circuits.	Explain that a multivibrator is essentially an oscillator which produces a square wave output. Point out that: (1) astable produces a continuous stream of rectangular waves, (2) monostable produces a single waveform upon being triggered, and (3) bistable changes its output voltage level upon being triggered. Demonstrate that the output of a multivibrator has two "states" -- high and low.	Multivibrator Circuits 1. Astable 2. Monostable 3. Bistable
8. Construct astable multivibrator circuits using transistors or ICs.	Review the relationship between frequency and period of a waveform: $f = \frac{1}{\text{Period}}$ Point out that Duty Cycle $= \frac{\text{Pulse Width}}{\text{Period}}$	
9. Calculate frequency and duty cycle of an astable circuit.	Work sample problems calculating frequency and duty cycle.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
10. Construct monostable circuits using transistors or ICs.	Provide an opportunity for students to build or experiment with monostable circuits. Encourage the use of oscilloscope to monitor the output of waveform.	
11. Calculate the output pulse duration of a monostable multivibrator circuit.	Demonstrate the use of appropriate formulas to calculate output pulse duration in a monostable multivibrator circuit using a 555 IC timer.	
12. Explain why bistable multivibrators are called flip-flops.	Discuss the operation of the bistable multivibrator. Point out that a "set" pulse flips the output to one state, while a reset pulse flops the output back to its other state.	
13. Demonstrate the operation of a bistable multivibrator using transistors of digital ICs.	Provide an opportunity to build or experiment with bistable circuits. Encourage students to design practical circuits which include the use of bistable multivibrators.	
14. Explain the function and operation of a Schmidtt Trigger.	Explain the operation of the Schmitt trigger. Have students observe that there are two critical input levels: "turn on" and "turn off" voltages, with the latter being somewhat lower than the former. Stress that the Schmitt trigger is used to provide rectangular output waveshapes from a wide variety of input signals.	Schmitt Trigger A bistable device used for pulse shaping.

ELECTRONIC COMMUNICATIONS SYSTEMS - EE301-04 (Option)

Major Objective: To understand the characteristics which are common to all electronic communications systems.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. INTRODUCTION TO COMMUNICATION SYSTEMS The student should be able to:		
1. Describe the evolution of electronic communication systems.	Review the history of communication. Emphasize major developments which led to the present state of electronic communication technology.	Understanding Communication Systems, Texas Instruments
2. Identify four characteristics of electronic communication systems.	Point out that communication systems can be composed on the basis of: (1) rate of information transfer, (2) reliability, (3) convenience, and (4) cost of operation.	Understanding Data Communications, Texas Instruments
3. Draw a simple block diagram and explain the function of the basic parts of an electronic communication system.	Have students draw a block diagram which might include: (1) information source, (2) encoder, (3) transmission, (4) link, (5) receiver, (6) decoder, (7) information user. Ask students to design a block diagram for a two-way electronic communication system.	Understanding Telephone Electronics, Texas Instruments
4. Give several examples of free-space communication systems and closed-link systems.	Discuss the advantages and disadvantages of closed-link systems using wire, optical fiber, etc.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
5. Define signal noise.	Discuss signal intelligence. Acquaint students with sources of noise in an electronic communication system. Point out that material noise may be produced by thunderstorms or may originate in outerspace. Stress that manmade noise comes primarily from electric motors and other electronic appliances.	Noise Any undesired signal not present in the original transmitted information.
6. Explain what is meant by signal-to-noise ratio.	Discuss signal-to-noise ratio. Explain that it is the ratio of the signal strength to the strength of the internal noise of a circuit.	
B. INFORMATION ENCODING The student should be able to:		
1. Distinguish between analog and digital encoding systems.	Examine output waveforms of a variety of electronic circuits including digital and analog. Ask students to compare differences between the analog (continuously varying) and digital signals.	
2. Define the term modulation.	Point out that most long-distance communication systems use a carrier frequency upon which information is encoded. Stress that traditionally, AM and FM have been the most popular forms of encoding or modulating a carrier. However, as the popularity of digital circuitry continues to increase, digital encoding will be more and more important.	Modulation The process of varying the amplitude, frequency or phase of a carrier wave, depending on how you want to transmit the signal. of a carrier wave, depending on how you want to transmit the signal.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Name and compare the characteristics of digital information encoding.	Identify digital encoding systems. Emphasize that PWM is sometimes refered to as Pulse Duration Modulation (PDM). Discuss the characteristics of PWM and PCM. Stress the freedom from noise in digital transmissions.	Types of Digital Information Encoding 1. Pulse Width Modulation (PWM) 2. Pulse Code Modulation (PCM)
4. Compare sine wave modulation techniques.	Review AM and FM encoding techniques. Have students describe how information is encoded into each system.	
5. Explain how sine waves can be converted to digital information.	Discuss the operation of an op amp comparator. Stress that by inputting a ramp signal on one input and the modulating signal information into the other input, the comparator will give a pulse train output with constant amplitude but varying widths.	
C. INFORMATION TRANSMISSION		
The student should be able to:		
1. Explain the difference between open-link and closed-link transmission systems.	Make students aware of the difference between free-space transmission of information vs open- and closed-link systems. Point out that free-space transmission refers to open broadcast through the	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
	atmosphere. With linked systems, a specific transmitter is directed to a specific receiver. Closed-link systems use fibers or cables to direct the signal to specific receivers. Discuss the problem of atmosphere interference with open-link systems.	
2. Give examples of several types of hand-wired transmission systems.	Ask students to discuss the advantage of hand-wired transmission systems. Responses should include: reliability, security, etc.	Hand-wired Transmission Systems 1. Telephone 2. Intercom 3. Closed-circuit TV 4. Computer network
3. Name several examples of free-space radiation systems.	Have students develop a list of free-space systems. Systems that might be mentioned include AM and FM radio, CB, TV.	
4. Compare the effectiveness of free-space and fiber-optic lightwave communication systems.	Discussion should focus on power requirements, simplicity, interference, losses, noise, health hazards.	
5. Explain the need for frequency and bandwidth regulation in free-space electromagnetic transmission systems.	Encourage students to consider the effects of zero regulation of commercial broadcasting. Focus on problems such as bandwidth overlap, interference, drift, etc.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
D. DECODING/DEMODULATION The student should be able to:		
1. Outline the processes involved in AM and FM demodulation circuits.	Review the basic differences in signal processing within AM and FM stations. Remind students that while the process of encoding information on a carrier signal is known as modulation, decoding the information is known as demodulation. Draw and have students copy schematics of AM and FM demodulator circuits. Point out that these circuits are often referred to as detectors. Discuss the operation of detector circuits in AM and FM applications.	
2. Explain the process by which digital information is decoded.	Point out that when digital information is decoded it may have to be converted back to analog signals. Operational amplifiers used as summing amplifiers are commonly used for digital-to-analog decoding.	
3. Identify types of selective filtering of unwanted signals.	Discuss the effects of filtering methods. Draw and ask students to copy generalized frequency response graphs of high-pass, low-pass, band-pass, and notch-filter circuits.	Types of Selective Filtering 1. High Pass 2. Low Pass 3. Band Pass 4. Notch

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
E. OUTPUT/DISPLAY		
The student should be able to:		
1. Explain the operation of the following output devices: seven-segment LED, CRT and liquid crystal display.	Review students' knowledge of output display devices. Present information and demonstrate operation of those not previously studied.	
2. Discuss future potential for new types of output display devices.	Ask students to investigate new types of output display devices, such as plasma screen for computers and flat screen TV picture tubes.	
F. STORAGE OF INFORMATION		
The student should be able to:		
1. Give examples and explain the operation of several types of electronic information storage.	Develop understanding of simple electronic memory devices, such as flip-flops and binary registers. Introduce RAM and ROM as more complex electronic memory circuits.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Name several types of magnetic information storage systems.	Ask students to name several magnetic information systems. Expand list to include computer diskettes, hard discs, as well as video and audio tapes.	
3. Describe recent developments in information storage technology.	Have students investigate innovative methods for information storage.	

TELEVISION - EE301-05 (Option)

Major Objective: To develop an understanding of the modern television system.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. INTRODUCTION TO TV The student should be able to:		
1. Identify the portion of the electromagnetic frequency spectrum allocated to TV broadcast transmission.	Review the electromagnetic frequency spectrum and locate AM radio, FM, and shortwave frequencies. Point out location of TV frequencies. Make students aware of the gaps in the TV channel frequency allocation. Discuss UHF and VHF.	
2. Compare the bandwidth allocations for a TV channel with that of AM radio stations and FM radio stations.	Discuss the need for the extremely wide bandwidth for TV. Focus discussion on the amount of detail required for proper encoding of video signal information. Compare the allowable drift for AM, FM, and TV carrier frequencies. Point out that the Canadian Department of Communications sets these standards.	Bandwidth TV = 6MHz FM = 200KHz AM = 10KHz Allowable Drift AM = 10Hz FM = 100Hz TV = 500Hz
3. Define audio and video.	Explain that in very simple terms, audio means "what we can hear" and video refers to picture information on TV.	Audio Sound or electrical signals from 20 Hz to 20,000 Hz. Video Pertaining to television picture information.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
4. Identify the type of modulation used for audio and video in television broadcast systems.	Review general concepts of amplitude and frequency modulation. Point out advantages to using AM for video and FM for sound.	Type of Modulation in TV Systems 1. Audio = frequency modulation 2. Video = amplitude modulation
5. Describe the limitations of line-of-sight television transmission.	Discuss reasons why TV signals do not bounce off the ionosphere. Illustrate the effects of curvature of the earth and transmitter antenna height. Discuss the growth of cable TV and satellite dishes as a means of overcoming the limitations of line-of-sight transmission.	
6. Draw a simple block diagram illustrating the main parts of a television broadcast transmitter and receiver.	As an aid to understanding the system, it is recommended that a series of block diagrams be developed, from extremely basic (audio, video and sync), leading to a more complete diagram showing all major circuits.	
7. Summarize the North American monochrome television broadcast standards.	Inform students that three major TV systems have been adopted around the world: (1) PAL, (2) SECAM, and (3) NTSC. Discuss NTSC standards of transmission.	Standards of Transmission 1. Scan picture lines at a uniform velocity left to right from top to bottom. 2. 525 scan lines per frame, two fields per frame.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
		3. 30 frames per second. 4. Vertical to horizontal aspect ratio of 4:3. 5. 6 MHz channel bandwidth. 6. Amplitude modulated video signal broadcast containing both picture information and synchronization signals. 7. Frequency modulated sound information broadcast 4.5 MHz above the picture carrier.
B. APPLICATIONS OF TV The student should be able to:		
1. Identify and explain the differences between various television systems which use cable distribution.	Point out that in addition to wireless transmission of TV signals, distribution may also be accomplished by coaxial cable. Distinguish between: (1) cable TV (CATV), (2) closed circuit TV (CCTV), (3) master-antenna television (MATV). Point out specific applications for each.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Briefly explain how satellites can be used to provide wide-area television coverage.	Relate discussion to the problem of line-of-sight transmission. Discuss the Canadian ANIK Satellite system.	ANIK Operated by TELESAT CANADA, used by CBC and Trans-Canada Telephone System.
3. Discuss the processes involved in home video tape recording systems.	Show a simplified diagram of a video cassette recorder. Stress the operation of (1) rotating heads, (2) start tracks, (3) modulator, and (4) external connections.	
4. Describe the basic operation of video disc systems.	Compare the video disc to video tape. Discuss methods of encoding audio and video in the surface of the disc. Investigate tracking systems.	
5. Compare the operation of one-tube and three-tube types of projection television systems.	Illustrate the basic parts of three-tube and one-tube TV projection systems. Discuss the operation of each system. Point out that the three-tube projection system is similiar to the reverse of the three-tube color camera.	
6. Discuss the operation of television video game accessories.	Present a typical video game block diagram and discuss its operation. Stress: (1) game chip, (2) oscillator, (3) video mixer, (4) modulator, (5) audio amplifier.	Television Electronics, 5th edition, Delmar

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
7. Describe the operation of interactive video text systems using the public telephone network.	Introduce applications for video text systems. Point out that this system uses public telephone lines. Discuss the functions of: (1) data terminal, (2) modem, (3) telephone system lines.	
C. TV PICTURE The student should be able to:		
1. List the principles involved in scanning the television picture.	Explain the horizontal and vertical movement of the electron beam on face of CRT. Stress: (1) trace and flyback, (2) lines per frame, (3) frames per second.	
2. Describe the picture qualities important in television.	Discuss picture qualities. Stress the difference between brightness and contrast.	Picture Qualities 1. Brightness 2. Contrast 3. Detail 4. Proportion

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Explain the difference between the television picture field and frame.	Describe the principle of interlacing fields.	Frame One complete TV picture. It consists of two fields and has a total of 525 lines. There are 30 frames per second. Field One-half of a TV frame, consisting of 262.5 scanning lines.
4. Discuss the function and importance of syncronization and blanking signals.	Point out the importance of having the studio camera and home TV receiver exactly in "sync". Ask students to imagine what would happen if they became out of sync.	
D. TV CAMERAS		
The student should be able to:		
1. Name the most commonly used television camera tubes and compare their operation.	Ask students to investigate early types of TV camera tubes. Compare them to current types of camera tubes.	Common TV Camera Tubes 1. Vidicon 2. Plumbicon 3. Saticon

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Compare the operation of a B&W video camera and a color camera.	Point out that color cameras are really three cameras in one. Make sure students understand the function of color filters and dichroic mirrors.	
3. Describe the process by which sync signals are mixed with video signals at the television broadcast station.	Discuss signal processing in the TV camera to produce composite video output. Emphasize the addition of blanking and sync pulses to video signal.	
E. PICTURE TUBES		
The student should be able to:		
1. Illustrate the basic construction of a picture tube.	Discuss the function and operation of a CRT. Discuss picture tube construction.	
2. Define the term deflection angle and explain how it is measured.	Point out that the deflection angle of early TVs was considerably smaller than today. Stress that wide deflection angle yields a shorter picture tube and smaller TV.	Deflection Angle The total angle through which the electronic beam can be deflected by the yoke.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Explain the numbering system used for picture tube identification.	Illustrate the method for identifying phosphor type and size and CRT. Demonstrate the use of the service manual to look up specs for a CRT. Provide opportunities for students to look up specs on CRTs.	
4. Outline the function of the aluminized phosphor screen backing used in modern CRTs.	Discuss the benefits of aluminized backing.	
5. Understand the function and operation of the electron gun assembly.	Illustrate the construction of the electron gun assembly. Discuss its operation.	
6. Describe the safety precautions which should be followed when handling picture tubes.	Stress the prevention of injury due to shock or implosion of a CRT.	
7. Compare electromagnetic and electrostatic deflection systems.	Point out that TVs use electromagnetic deflection, while oscilloscope CRTs use electrostatic deflection.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
8. Explain the function of the shadow mask.	Illustrate the function of shadow mask.	
9. Outline some of the common troubles associated with picture tubes and discuss how to deal with them.	Provide an opportunity for students to analyze the symptoms of defective CRTs. If a CRT tester is available, provide experience in its use to determine the quality of a CRT.	
F. COMPOSITE VIDEO SIGNAL		
The student should be able to:		
1. Make a drawing which illustrates the basic shape of the amplitude modulated video carrier wave.	Draw a portion of the video signal, illustrating a portion of one line of picture information. Correlate changes in signal amplitude to changes in light intensity of the picture being scanned.	
2. Explain the process by which the modulated video carrier is converted into the composite video signal.	Point out the addition of blanking pulses and sync pulses to the video carrier's signal.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Make a drawing to illustrate the composite video signal.	Draw and have students copy an illustration of a composite video signal. Emphasize camera signal, horizontal and vertical blanking pulses.	
4. List the advantages of negative picture transmission.	Discuss the effect of atmospheric noise on AM signal transmission. Point out that picture information is less affected by lightning, etc., when negative signal transmission is used.	
5. State the frequencies for video line rate, field rate, and frame rate.	Review: (1) scanning principles, (2) horizontal and vertical scan frequencies, (3) field and frame rate, and (4) number of lines per frame. Show the relationship by the formula: Horiz. Scan Freq. = Lines per Frame x Frames per Second = 525 x 30 = 15,750	
6. Discuss the importance of the average or DC component of the video signal.	Point out the relationship between the DC component of the video signal and the brightness of the picture. Show how control of the DC component value allows for adjustment of picture brightness in the receiver.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
G. TV CIRCUITS The student should be able to:		
1. Draw a functional block diagram of a monochrome television receiver and explain the function of each block.	Ask students to draw and discuss a detailed block diagram of the black-and-white TV receiver. Encourage students to add signal waveforms throughout to indicate an understanding of how each stage affects the signal.	
2. Name and identify the purpose of the external controls on a monochrome television.	Demonstrate the effect caused by adjustment of external controls on receiver. Ask students to rectify adjustment problems on misadjusted TVs.	External Controls 1. Channel selector 2. Volume 3. Contrast 4. Brightness 5. Vertical hold 6. Horizontal hold
3. Explain the process by which television channels are tuned.	Discuss the operation of the TV channel selector. Compare the tuning of UHF and VHF signals.	
4. Describe how picture-tube high voltage is produced.	Stress the importance of sync signals in production of high voltage on the anode of the CRT.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
5. Explain the action of the automatic gain control (AGC) circuit.	Relate the action of the AGC to that of the automatic gain control of the superhetrodyne radio. Stress that AGC in a TV affects the video signal.	
6. Explain or demonstrate how to align a B&W receiver using an oscilloscope and RF sweep generator.	Encourage students to develop an awareness of the process of alignment of a B&W receiver.	
7. Apply appropriate troubleshooting skills to identify symptoms, isolate faulty circuits, and make repairs to defective parts in televisions.	Discuss general troubleshooting skills. Stress the analysis and isolation of circuit faults in TV receivers.	
8. Demonstrate safe practices in the repair of television circuitry.	Emphasize the need for safety in TV work. Point out the dangers involved in working around the high voltage circuits.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
H. CABLE TV The student should be able to:		
1. Explain the advantages of cable television distribution systems.	Stress: (1) signal strength (2) extended channel selection (3) ghost-free picture	
2. Outline the main parts of cable distribution systems.	Present a block diagram of a cable system. Discuss: (1) signal source (2) head end (3) line amplifiers (4) coaxial cable distribution system (5) impedance matching transformer (75Ω:300Ω)	
3. Explain why cable television station frequencies may differ from standard television broadcast frequency allocations.	Make students aware that because cable signals are not broadcast through free space, they need not conform to approved channel frequencies.	
4. Explain the purpose of cable television converters.	Review the concept of hetrodyning. Describe how the converter changes all channels to a lowband VHF channel, usually 3 or 4. Point out the advantage of converters in a cable system.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
I. TV SYSTEMS AROUND THE WORLD		
The student should be able to:		
1. Compare NTSC system standards to other systems.	Review three types of TV systems around the world: (1) NTSC (2) PAL (3) SECAM List countries served by each system. Discuss: (1) horizontal and vertical scan frequencies (2) number of lines per frame (3) video signal bandwidth (4) channel bandwidth (5) picture carrier modulation (6) positive and negative picture transmission	

DIGITAL CONCEPTS AND MICROPROCESSORS - EE301-06 (Option)

Major Objective: To understand digital electronic circuits and their role in modern computers.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. INTRODUCTION TO DIGITAL TECHNOLOGY The student should be able to:		
1. List the advantages of digital circuits in electronic equipment.	Discuss the trend towards digitalization in many areas of electronics. Emphasize computers, audio recordings, communications, fiber optics.	Logic & Memory Experiments, Howard Sans Publishers Z-80 Microprocessors, Howard Sans Publishers Digital Techniques, Heathkit
2. Identify the semiconductor devices used in digital circuits.	Point out that early digital computers used vacuum tubes. Ask students to discuss reasons for the almost universal use of solid state semiconductors in modern digital circuits.	Semiconductor Devices in Digital Circuits 1. Diodes 2. Transistors 3. Integrated circuits
3. Name the two main IC families used in digital circuits and discuss their differences in construction.	Acquaint students with the basic differences in construction of the two IC families. Point out that both TTL and CMOS perform the same functions.	IC Families 1. TTL (Transistor Transistor Logic) 2. CMOS (Complementary Metaloxide Semiconductor)

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
4. Compare the characteristics of TTL and CMOS ICs.	Discuss the characteristics of TTL and CMOS ICs. Provide an opportunity for students to construct TTL and CMOS digital circuits.	TTL Characteristics 1. Higher operating speeds 2. Capable of carrying more current 3. Much lower resistance when turned on 4. Less expensive CMOS Characteristics 1. Very low power consumption 2. Much greater fanout 3. Require special handling to prevent destruction by static discharges
5. Define the term fanout.	Compare the fanout capabilities of TTL and CMOS. Stress that where many gates must be driven by a single output, CMOS is preferred.	Fanout The characteristic that indicates how much of a load can be connected to the output of a digital circuit. It is usually expressed as the number of inputs to other logic gates that a logic circuit can drive.
6. Describe the output waveform from digital circuits.	Point out that digital circuits produce a square wave output.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
7. Compare serial and parallel data transfer.	Discuss the speed of data transfer and the number of bus connections required.	Serial Data Transfer The transmission of data sequentially over a single wire. Parallel Data Transfer Transmission of data where all the bits of a binary word are transferred simultaneously via a multi-wire bus. Parallel data is much faster than serial, but more expensive due to the multi-wave bus circuitry required.
B. NUMBER SYSTEMS The student should be able to:		
1. Name the number systems most commonly used in digital circuits.	Give examples of numbers written in the decimal, binary, and hexadecimal systems commonly used.	
2. Convert decimal numbers to binary and hexadecimal.	Demonstrate how to convert numbers from one system to another. Provide practice problems for students to develop this skill.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Identify the advantage of using binary numbers in digital electronic systems.	Remind students that because digital circuits have two states, "high" and "low", they are ideal for the application of the binary number system.	Advantage Its two-digit arrangement can easily be adapted to simple two-state (on-off) switching circuits.
4. Distinguish between standard binary and binary coded decimal (BCD).	Compare examples of numbers written in standard binary to numbers written in BCD. Point out the advantage of BCD when required to write out large numbers. Ask students to demonstrate their ability to convert numbers to the BCD system.	BCD A form of binary notation in which each decimal digit is expressed by a 4-bit binary equivalent (eg: 35 = 0011 0101).
5. Describe the operation of digital IC encoders and decoders.	Demonstrate and have students construct circuits using IC encoders and decoders.	
C. LOGIC ELEMENTS (Gates) The student should be able to:		
1. Name common logic gates and draw their standard symbols.	Point out that the building blocks of digital circuitry are logic gates. Name and illustrate the symbols for the six basic logic gates.	Logic Gates 1. AND 2. OR 3. NOT 4. NAND 5. NOR 6. Buffer

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Explain the function of each of the basic logic gates.	Demonstrate the operation of the basic logic gates.	
3. Explain why logic gates are referred to as "decision making" circuits.	Point out that each logic gate can only make a very simple decision, based on its input conditions and a pre-arranged set of operating rules. However, many gates can be grouped together to make very complicated decisions very rapidly. Stress that decision making logic gates are the heart of every digital computer.	
4. Develop and explain the importance of truth tables for the common logic gates.	Ask students to copy and discuss truth tables for common logic gates. Encourage students to develop the ability to identify logic-gate functions represented by various truth tables.	Truth Table A listing of all the possible combinations of input and output for a logic gate.
5. Compare positive and negative logic.	Discuss positive and negative logic. Investigate the effect which negative logic has on the truth table of common logic gates. Output voltage levels from digital circuits may be "high" (close to power supply voltage) or "low" (close to ground). In positive-logic circuits, the most positive voltage represents a digital "1" and the least positive signal represents a digital "0". In	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
	negative-logic circuits, the most negative (or least positive) output signal represents digital "1" while the least negative (or most positive) signal represents a digital "0".	
6. Write Boolean logic expressions for the various logic gates.	Discuss Boolean algebra and demonstrate how combinations of logic gates can be expressed mathematically.	
7. Simplify logic circuit expressions using Boolean algebra.	Demonstrate how complex logic expressions can sometimes be simplified by Boolean algebra. Explain that this technique can help produce simpler, less expensive digital circuits.	
8. Demonstrate the operation of common logic gates by constructing experimental circuits.	Provide an opportunity to build functional or experimental circuits which demonstrate the operation of the six logic gates.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
D. MEMORY CIRCUITS The student should be able to:		
1. Define sequential logic circuit.	Define sequential logic circuit and emphasize that its primary characteristic is memory.	Sequential Logic Circuit A logic circuit in which a certain sequence of events (or input signals) must occur before the output event (signal) will occur.
2. Name the simplest digital memory circuit.	Point out that the simplest form of digital memory is the flip-flop, which can store one bit of digital information. Stress that larger and more complicated electronic memory circuits are made up of many flip-flops.	
3. Draw the symbols for common flip-flops.	Draw and have students copy standard symbols for RS, D-Type, and J-K flip-flops.	Common Flip-Flops 1. R-S 2. D-Type 3. J-K Type

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
4. Compare the characteristics of common flip-flops.	Discuss the operation of RS, D-type, and J-K type flip-flops. Provide an opportunity for students to experiment with or construct circuits using flip-flops.	
5. Demonstrate how flip-flops can be made from combinations of simple logic gates.	Demonstrate a schematic for a flip-flop using NAND gates. Discuss the operation of the circuit.	
6. Define and explain the purpose of a register.	Point out that microprocessors and computers frequently need to store data for later use. Show a block diagram of a microprocessor and discuss the purpose of registers therein.	Register A group of flip-flops used for temporary storage of binary digits or words.
7. Compare the operation of serial and parallel shift registers.	Outline the operation of serial and parallel shift registers. Make students aware of the speed of data transfer in systems using parallel shift registers.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
8. Define binary counter.	Show how J-K flip-flops can be cascaded with the output of one feeding the input of the next. Demonstrate the ability of the circuit to count input pulses and express the number in pure binary output.	Binary Counter A sequential logic circuit made up of flip-flops that are used to count the number of input pulses applied to it.
9. Explain the operation of asynchronous and synchronous counters.	Make students aware that the term, asynchronous, comes from the fact that the flip-flops are not being controlled by a clock. Compare the advantages and disadvantages of synchronous and asynchronous counters.	Asynchronous Counters A series of flip-flops connected so the output of one drives the input of the next. Sometimes referred to as "ripple counters". Synchronous Counters Counters that are controlled by clock pulses. Synchronous counters are capable of faster operation than asynchronous counters.
10. Demonstrate the operation of binary and BCD counters using J-K flip-flops.	Provide an opportunity for students to build or experiment with binary and BCD counter circuits.	
11. Demonstrate the use of IC counters as frequency dividers.	Show how the output of binary counters provide a simple frequency dividing network. Provide an opportunity for students to build and demonstrate the operation of frequency dividers using an IC such as 74193.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
12. Explain the importance of clock pulses in sequential logic circuits.	Discuss the need for precise timing pulses so that all flip-flop outputs change at exactly the same time. Stress the importance of simultaneous data transfer between circuits in systems such as microprocessors and computers.	
13. Demonstrate how to construct an astable multivibrator clock circuit using digital logic gates.	Point out that while clock circuits can be made from discrete components, it is simpler to use the 555 IC timer or TTL inverters. Provide a schematic for a clock circuit using TTL inverters and have students build the circuit. Ask students to measure or calculate the frequency of their clock circuit.	
E. COMPUTER SYSTEMS The student should be able to:		
1. Draw a block diagram showing the main parts of a digital computer.	Prepare a brief outline of the history of the modern electronic digital computer. Point out that all computers have the same basic parts: (1) input/output, (2) control unit, (3) arithmetic logic unit, and (4) memory.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Name several examples of computer input and output devices.	Ask students to list a variety of input and output devices commonly found on computers today. Discuss possible future trends in input/output devices for computers.	
3. Identify the main types of computer memory circuits.	Discuss the purpose of read-write memories and read-only memories. Point out that most read-write memories are random access (RAM). Stress that some types of RAM are programmable and erasable.	Electronic Memory Circuits 1. Random access memory (RAM) 2. Read only memory (ROM)
4. Explain the difference between volatile and non-volatile memories.	Stress that "glitches" in the power system must be controlled in order to prevent loss of data in volatile RAM circuits.	Volatile Memory The electronic memory circuits that lose all stored data when the power is removed. RAMs have volatile memory circuits. Non-Volatile Memory The memory circuits that have data permanently stored at the time of manufacture. Loss of power does not destroy memory contents. ROMs are non-volatile.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
5. Compare PROMs and EPROMs.	Stress that while EPROMs can be reprogrammed, this is not a feature which currently has value to the average consumer, but rather to owners of large computers.	Programmable Read-Only Memory Data is stored permanently by the user after the chip is manufactured, and cannot be changed afterwards. Eraseable Programmed Read-Only Memory Using special equipment, this type of memory chip can be erased and reprogrammed.
6. List several external bulk memory devices.	Compare the cost, capacity and speed of types of external bulk memory devices.	External Bulk Memory 1. Punched card 2. Paper tape 3. Magnetic tape 4. Magnetic disc or drum
7. Describe the operation and advantages of several types of external bulk memory devices.	Make students aware that external bulk memory devices include: (1) magnetic disc (2) magnetic drum (3) magnetic tape Stress that while external bulk memories can store large amounts of information, their access time is very slow.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
F. MICROPROCESSORS		
The student should be able to:		
1. Explain the function of the microprocessor unit (MPU) within the digital computer.	Refer to the block diagram of a computer and discuss the role of the MPU.	
2. Draw a block diagram and explain how instructions and data are processed within the MPU.	Draw and discuss a detailed block diagram of a typical MPU including: (1) arithmetic logic unit (ALU) (2) data register (3) instruction decoder (4) controller-sequencer (5) accumulator (6) program counter (7) address register	
G. PROGRAMMING The student should be able to:		
1. Define program, algorithm, flow chart, loop, coding, and machine language program.	Discuss the importance of programming. Do not attempt to develop extensive programming skills, but rather a very general understanding of the role of programming in computers today.	Program A detailed set of instructions (sometimes referred to as "software") that tells a computer exactly what to do.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
		Algorithm Any problem which can be broken down into a series of small choices that can be made in yes-or-no terms. Flow Chart A map of the way a program will work. A flow chart helps the programmer visualize logical progression of the algorithm. Loop A series of program steps that are repeated a number of times. Machine Language Program A program in which all instructions are coded in their binary word equivalents and then loaded into the computer.
2. Write a simple machine language program and explain or demonstrate how the computer processes each instruction within the program.	Provide a brief comparison between BASIC programming and machine language programming. Provide several samples of simple machine language programs (ie: add two numbers and store the sum). Discuss how the data is processed by the computer while executing these programs.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
H. TROUBLESHOOTING DIGITAL CIRCUITS		
The student should be able to:		
1. Apply safe practices in troubleshooting digital circuits.	Review general safety rules that apply to situations involving work with electrical circuits. Point out that while digital circuits tend to operate on low voltages, care must be taken while working around power supplies and bus lines.	
2. Demonstrate appropriate skill in troubleshooting digital circuits.	Provide an opportunity for students to develop skills in the use of digital logic probes.	

FIBER OPTICS - EE301-07 (Option)

Major Objective: To provide an understanding of the operation of a fiber optics communication system.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. OPTICAL ENERGY The student should be able to:		
1. Define light.	After reviewing the definition of light, point out that light can be generated by: (1) incandescence, or (2) luminescence.	Link II, Motorola Incorporated Fiber Optics, Heathkit Light An electromagnetic radiation including infrared, visible, and ultraviolet rays with a speed of approximately 300 million meters per second when travelling through a vacuum. Incandescence Generation of light by an extremely hot body. Luminescence Generation of light by any means other than incandescence, especially at "cold" temperatures.

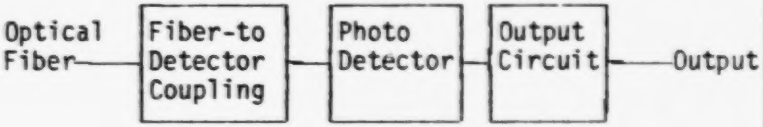
OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Compare the concept of geometrical optics to physical optics.	Review the dual nature of light: (1) travels through space like radio waves, (2) acts like it is made up of small particles. Introduce geometrical optics and physical optics.	Geometrical Optics The study of light as "rays" that radiate in all directions from a source. Physical Optics The study of phenomena which have a bearing on the nature of light. Physical optics describe light as "wave-like" radiation.
3. Define the terms reflection, refraction, absorption, and diffusion.	Define and ask students to demonstrate or describe examples of reflection, refraction, absorption and diffusion.	Reflection A change in the direction of a light beam as it strikes a smooth polished surface. Refraction The bending of a light wave when it passes from one medium to another. Absorption The loss of light energy as it travels through a medium. Diffusion The scattering of light rays.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
4. Demonstrate the effect of simple concave and convex lenses on light beams.	Ask students to set up a demonstration which illustrates the expansion or compression of a light beam by means of a simple lens.	
5. Describe the function of optical components such as the prism and filters.	Demonstrate the dispersion of light through a prism. Repeat the demonstration using a filtered beam of light and note the effect on light dispersed by the prism.	
B. LIGHT SOURCES The student should be able to:		
1. Explain the operation of light-emitting diodes.	Review the operation of GaAsP and GAP LED's. Discuss the wave length of light given off by each.	
2. Explain the meaning of coherent light.	Describe the nature of light and compare this to coherent light waves.	Coherent Light When all light waves are caused to vibrate in phase, with the resulting waves having much greater amplitude (intensity) than the initial waves.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Explain the operation of the ruby laser.	Present a simplified diagram showing the basic parts of a ruby laser. Discuss the process by which coherent light is produced in the ruby laser. Point out that the laser is by far the most expensive fiber optic light source.	
4. Explain the operation of laser diodes.	Make students aware that lasers are made in several forms: (1) solid state lasers (2) gas lasers (3) liquid lasers (4) semiconductor lasers (laser diodes) Explain the operation of the laser diode.	
C. OPTICAL FIBERS The student should be able to:		
1. Discuss the history and evolution of fiber optics.	Discussion should include: (1) Tyndal's 1870 demonstration of light following a stream of water (2) light transmission through fibers in 1930's (3) development of fiber optic technology in the 1950's (4) dramatic improvements in quality and cost of fibers during the 1960's (5) geometric growth of industry in the 1970's	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Compare the methods of light transmission (propagation) within optical fibers.	Illustrate the principle of critical angle which prevents light from escaping from the walls of a glass fiber. Contrast this to the concept of continuous refraction which involves a more complex fiber care structure.	Methods of Light Propagation within an Optical Cable 1. Total internal reflection 2. Continuous refraction.
3. List types of losses that occur in fiber optics systems.	Point out that glass fibers do not have 100% efficiency in light propagation. Compare light energy losses due to attenuation and dispersion. Ask students to research specific losses common to fiber optic systems.	Losses in Fiber Optic Systems 1. Attenuation 2. Dispersion Attenuation is the loss of light amplitude (intensity) while dispersion is the loss of signal intelligence as a result of distortion.
4. Describe the construction of optical fibers.	Provide illustrations showing the construction of a variety of optical fibers and cables. Point out that design of the cable depends upon its application, and the stress to which it will be subjected.	Types of Optical Fibers 1. Single fibres 2. Bundled fibres
5. List the types of materials used to manufacture optical fibers.	Make students aware that glass has superior optical qualities, while plastic fibers are less expensive. Plastic-clad glass fiber is sometimes used as a compromise.	Materials Used to Manufacture Optical Fibers 1. Glass (fused silica) 2. Plastic

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
6. Explain how the construction of a fiber optic LED is different from a standard LED.	Stress that fiber optic LEDs are similiar to standard LEDs, except that they produce a more intense light in a tighter beam. Point out that this makes their construction more expensive than standard LEDs.	
D. RECEIVERS The student should be able to:		
1. Describe the function of an optical receiver.	Point out that the purpose of the optical receiver is to convert the optical signal from the transmitter into an electrical signal, which it then amplifies, demodulates, and converts to the appropriate output signal.	
2. Identify the major photodetector devices and explain their operations.	Provide an opportunity for students to experiment with a variety of photodetector devices.	Devices suitable for use as Photodetectors 1. Photoconductive and photoresistive cells 2. Photodiode 3. Phototransistor 4. Photo-Darlington circuit 5. PhotoFET 6. Light activated SCR 7. Photomultiplier tube

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Draw a block diagram showing the basic parts of a simple photodetector receiver circuit.	 Optical Fiber Fiber-to Detector Coupling Photo Detector Output Circuit Output Optical Receiver Explain that a simple distance photodetector receiver circuit includes a coupler, photodetector, and output circuits.	
E. FIBER OPTIC SYSTEMS The student should be able to:		
1. Identify three classifications of data transmission standards for fiber optics communication systems.	List the three classifications of data transmission standards and outline their characteristics.	Fiber Optic Communication Systems 1. Simplex, or one-way link consisting of a single transmitter and receiver 2. Half duplex, a two-way link allowing communication in only one direction at a time 3. Full duplex, a two-way link allowing simultaneous transmissions in both directions

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Describe the basic function of a repeater in a long-link fiber optics system.	Make students aware that because of internal losses within optical fibers, repeaters (amplifiers) must be installed at regular intervals, usually every few kilometers. Stress that each repeater is a possible breakdown point in the system and they make the system more expensive. Thus, it is important to minimize fiber attenuation and keep the number of repeaters down.	Repeater Function 1. Amplify the signal 2. Reshape the signal 3. Retransmit the signal

ROBOTICS/INTERFACING - EE301-08 (Option)

Major Objective: To introduce the student to robotics and robot technology.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. HISTORY AND EVOLUTION The student should be able to:		
1. Describe early inventions which led to the evolution of the modern robot.	Ask students to prepare reports on early fore-runners of the modern robot.	Robotics, McGraw-Hill The Robotics Revolution, Simon & Schuster Working Robots, Hayden Robotics: An Introduction, Breton Robotics Age: In the Beginning, Hayden
2. Define robot.	Make students aware that the origin of the word "robot" is from the Czechoslovakian word "robotta", meaning degrading or menial work. Ask students to look up modern definitions and discuss.	Robot "A reprogrammable, multifunctional manipulator designed to move material, parts, tools or specialized devices, through variable programmable motions, for the performance of a variety of tasks." (According to the Robot Institute of America)

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Describe how robots are currently used in industry.	Have students list ways in which robots have been adapted in industry.	
4. Define controller, manipulator, actuation, degrees of freedom.	Discuss robot terminology. Outline the basic parts of a robotic system: (1) controller (2) manipulator (3) power source Discuss the function of each of the basic parts of a robotic system.	Controller Any programmable device which initiates and controls the movements of robot mechanism. Actuator The drive mechanisms which position robot manipulators to desired location. Degrees of Freedom The axis of movement which a robot has. The complexity of the task a robot can perform is determined by the number of axes it has. Manipulator Arm of the robot.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
5. Distinguish between low-technology and high-technology robots.	Point out that robots are classified by their levels of technology. Compare low-tech and high-tech systems.	Low-Technology Robots 1. Suitable for limited sequence tasks 2. Have between two and four degrees of freedom 3. Have only two positions for each axis to assume (eg. up/down, right/left, in/out) High-Technology Robots 1. Can perform a wide variety of complex tasks 2. Have up to six or more degrees of freedom.
B. SENSORY FEEDBACK SYSTEMS The student should be able to:		
1. Describe examples of feedback control systems.	Discuss the principles of the mechanical governer invented by James Watt. Ask students how this mechanism provided feedback. Discuss how a household thermostat serves as a feedback control system.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Explain how robots can be equipped with sensors for heat, light, pressure, and sound.	Have students investigate sensing techniques used by robots. Have students identify a variety of common electronic components used as sensors in robotic systems; ie, thermistors (heat), opto-electronic devices (light), piezoelectric crystals (pressure), and ultrasonic detectors (sound).	
3. Describe how various sensor components operate.	Discuss the operation of thermistors, opto-electronic devices, piezoelectric crystals, and ultrasonic transducers.	
4. Outline the process of voice recognition by a robot.	Have students investigate the voice-recognition process in robotic systems.	
C. ROBOTIC ARMS The student should be able to:		
1. Name the joints found in robotic arms.	Make students aware that robotic arms may have the same joints as the human arm; however, low-tech systems may have only one or two joints.	Robotic Arm Joints 1. Shoulder 2. Elbow 3. Wrist 4. Gripper

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Compare the number of movements possible for a robotic arm with the number of movements possible for the human arm.	Ask students to consider the minimum number of joints required to allow an arm (human or robotic) to move any place in its sphere of influence. Define degrees of freedom and point out that the human arm has 42 degrees of freedom--far more than most robotic systems.	Degrees of Freedom The number of axis of motion.
3. Explain the function of the manipulator and the gripper.	Make students aware that the manipulator is simply the robot arm. Point out that the function of the manipulator arm is to position the gripper.	
D. ROBOT POWER-DRIVE SYSTEMS The student should be able to:		
1. Identify a variety of robotic power systems.	Have students investigate electric, hydraulic and pneumatic power-drive systems used in robots.	
2. Compare the operation of stepper motors and standard DC motors.	Review the operation of standard DC motors and then have students investigate.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
E. ROBOTICS AND THE FUTURE The student should be able to:		
1. Predict future uses for robots in the home and in industry.	Ask students to examine potential uses of robotics in personal and business applications. Encourage creative thinking.	
2. Describe some of the social implications of widespread use of robots in industry.	Have students consider some of the social implications involved in widespread use of robots in industry. Discuss possible effects on productivity, unemployment, etc.	

RESIDENTIAL WIRING - EE301-09 (Option)

Major Objectives: To provide students with an in-depth study of residential wiring practices.
To enable the student to estimate costs involved in residential wiring jobs.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. REVIEW		
The student should be able to:		
1. Recall basic residential wiring safety procedures discussed in Electricity /Electronics 101.	Review safety procedures for residential wiring.	
2. Recall basic residential electrical symbols and circuit wiring practices presented in Electricity /Electronics 101.	Ask students to draw symbols for common housewiring devices.	
B. TOOLS AND EQUIPMENT		
The student should be able to:		
1. Describe the care and use of tools and equipment for residential wiring.	Discuss the inspection, maintenance, and use of residential wiring tools. Encourage students to be responsible for regular inspection of tools in the IA lab.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Explain the use of clamp-on meters.	Demonstrate the use of clamp-on meters. Discuss their advantages.	
3. Understand the use of conduit benders.	Explain and demonstrate procedure followed for bending conduits. Discuss differences between hand benders and hydraulic benders.	
C. BLUEPRINT READING		
The student should be able to:		
1. Explain why electrical symbols and notations are used on electrical drawings.	Point out that symbols and circuit drawings are like a language through which we communicate a great deal of information. Stress the need for standard symbols and notations.	
2. Calculate the occupied floor area of a residential dwelling.	Discuss the importance of floor area of a dwelling when estimating electrical service required for a new home. Demonstrate how to calculate occupied floor area.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. Determine the total load requirements in amperes for general lighting in a dwelling.	Point out that lighting requirements are based on floor space in a dwelling. Work sample calculations and then ask students to do them. Explain that lighting standards call for 3 watts per square foot of floor space in a residence. $\text{Amperes} = \frac{\text{Watts}}{\text{Volts}}$	
4. Determine the number of lighting branch circuits required for a residential dwelling.	Provide a floor plan of a dwelling and ask students to establish the number of lighting branch circuits. Explain that branch circuits may include up to 12 lighting fixtures per circuit. Note: Lights need not be on separate circuits.	
5. Determine the number of small appliance branch circuits required.	Ask students to draw in duplex outlets on a floor plan. Explain that code requirements call for a maximum of 12 duplex receptacles per branch circuit.	
D. SERVICE ENTRANCE		
The student should be able to:		
1. Define service drop, service entrance, underground service.	Define and discuss service entrance. Make students aware of underground and above-ground service entrances.	Service Drop Utility wires running from the he last pole to the connection on t service entrance cable on the dwelling.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
		Service Entrance All wiring and equipment from utility wire connections on the dwelling to the residential circuit breaker box inside. Underground Service Utility wires which deliver service to dwelling by means of a special buried cable.
2. Identify the basic parts of the service entrance.	Discuss parts required for a complete service entrance. Make students aware that meter sockets are not required for farm houses.	Basic Parts of Service Entrance (1) Mast kit (2) Meter socket (3) Service entrance panel (SEP) (4) Grounding system
3. Describe proper placement of a SEP.	Provide examples of a number of site plans and ask students to discuss proper placement of a SEP.	Placement Factors of SEP 1. Location of utility connection 2. Location of major appliances 3. Minimum height above floor
4. Use electrical code book to determine conductor size for service entrance drop.	Discuss the conductor size required for 100-amp and 200-amp services. Ask students to look up wire size for a service entrance in the code book.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
5. Explain the grounding system used for a SEP and bonding of all service entrance equipment.	Point out that the SEP should be grounded to the water line or ground rod.	
6. Describe various types of fuses and circuit breakers.	Discuss the advantages of various protection devices.	
7. Explain the operation of fuses and circuit breakers.	Discuss and compare the operation of fuses and circuit breakers.	
8. Select the proper size fuse or circuit breaker for a particular installation.	Explain how the proper size circuit breaker is determined.	
E. DEVICES The student should be able to:		
1. Describe the construction and operation of common lighting devices.	Demonstrate the operation of a fluorescent light system. Discuss basic parts. Outline repair procedures. Have students wire a complete split switched outlet circuit.	Common Lighting Devices 1. Incandescent lamps 2. Fluorescent lamps 3. Mercury lamps

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Understand the code requirements relating to the installation of surface mount and recessed lighting fixtures.	Have students study the code for installation of lighting fixtures. Stress the use of BX loom with glass over thermoplastic insulation.	
3. Explain the need for forced ventilation in residential dwellings.	Discuss the fact that forced ventilation is required to reduce excessive moisture, odor, or heat-buildup in the home.	
4. Identify several areas in the home which may require forced ventilation.	Ask students to consider types of ventilating stems appropriate for attic, kitchen, or bathroom.	
5. Describe the types of forced ventilation devices commonly used in the home.	Identify and compare types of forced ventilation devices.	
6. Understand the operation of 4-way switches.	Draw a schematic of 4-way switch circuit. Draw a wiring diagram of 4-way switch circuit. Wire 3-way and 4-way switch circuits.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
7. List examples of where 4-way switches might be used.	Have students identify situations where 4-way switches might be used. Discuss the need for 4-way circuits in some hallways, outside entrances, stairways, etc.	
8. Explain the operation of low-voltage remote control systems for lighting.	Discuss the operation of low-voltage remote control lighting systems. Ask students to identify advantages of such a system.	
F. CONNECTORS AND SPLICING DEVICES. The student should be able to:		
1. Identify types of connectors and couplers used on a service entrance.	Ask students to wire a service entrance mock-up, and identify all service parts.	Types of Connectors/Couplers on Service Entrance (1) Screw type (2) Water-tight (3) Rigid (4) LB and TB type (5) LL and LR type

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Identify types of connectors found on ground systems.	Show examples of a variety of connectors found on ground systems. Have students identify any they have in their own homes.	Types of Connectors on Ground Systems (1) Grounding bushings (2) Ground clamps (3) Ground rod (4) Split-bolt connectors
G. HEATING SYSTEMS The student should be able to:		
1. Identify types of residential electrical heating systems.	Compare the function of primary and secondary electrical heating systems. Wire up thermostats and baseboard circuits.	Types of Electrical Heating Systems (1) Primary heating systems (2) Secondary heating systems
2. Describe the types of primary heating systems commonly found in residential dwellings.	Have students investigate and prepare a report on the operation of baseboard heaters, radiant cables, and electric furnaces.	Primary Heating Systems (1) Baseboard heating (2) Radiant cables (3) Electric furnace
3. Explain the operation of secondary heating systems.	Create an awareness of the operation of secondary heating systems, such as baseboard heaters, radiant panels, and infrared heaters.	Secondary Heating Systems (1) Baseboard heaters (2) Radiant panels (3) Infrared heating

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
H. ESTIMATING COSTS The student should be able to:		
1. Determine the placement of electrical devices on a residential floor plan.	Require students to do an estimate of costs required in complete wiring of their own homes.	16mm Film: "Basic Wiring". Manitoba Education
2. Determine the materials required to wire a complete residential dwelling.	Using a given dwelling, ask students to prepare a list of materials required to completely wire the structure.	
3. Estimate the cost of materials required for complete wiring of a home.	Have students complete an estimate of cost of materials to wire a dwelling.	
4. Determine labor costs for wiring a residence.	Encourage students to contact local electrical contractors for information concerning labor costs.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
I. AC MOTORS The student should be able to:		
1. Name the various kinds of single-phase induction AC motors.	Discuss the various kinds of AC motors. Identify the basic AC motor parts. Show students samples where possible.	Single-Phase Induction AC Motors 1. Shaded Pole 2. Synchronous 3. Split Phase 4. Capacitor Start 5. Capacitor Start and Run 6. Two-Value Capacitor Start and Run 7. Repulsion Induction Other Single-Phase AC Motors 1. Repulsion 2. Universal
2. Draw the schematic symbols for some of the AC motors.	Ask students to draw the various symbols. Point out the differences in the types of AC motors. Present some of the different types of AC motors. Discuss factors to consider when replacing electric motors; ie, horsepower, housing type, starting torque, etc.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
3. List several applications for the various single-phase AC motors.	Present some of the different applications of AC motors.	
4. Explain the need for the various starting arrangements in AC motors.	Stress the need for the assorted starting systems in the motors. Point out how the starting torque varies in the motors.	
5. Identify motor enemies and how to limit them.	Have students list the motor enemies and discuss how to minimize them.	Motor Enemies 1. Water 2. Dust 3. Friction 4. Vibration 5. Overload 6. Underload 7. Misalignment 8. Improper lubrication
6. Identify the types of motor housings.	Show students the types of enclosures.	Types of Housings 1. Open (Drip Proof) 2. Splash Proof 3. Dust Proof 4. Explosion Proof

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
8. Explain the basic difference between single-phase and three-phase motors.	Point out that single-phase motors produce a pulsating magnetic field, while three-phase motors produce a rotating magnetic field.	
9. List the two types of three-phase motors.	Discuss three-phase motor rotors: wound and squirrel cage.	
10. Explain the function of an automatic motor starter.	Discuss the operation of a magnetic (electromagnetic) motor starter unit.	

CAREER EXPLORATIONS - EE-301-10

Major Objectives: To provide the student with an understanding of the careers open to persons with some training in Electronics.
To learn how to investigate potential careers and apply for jobs.

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
A. CAREER CLASSIFICATION		
The student should be able to:		
1. Distinguish between occupations and careers.	Point out that occupations are jobs, while a career relates to one's advancement or progress in a vocation or occupation.	
2. Identify a variety of occupations related to the study of Electricity/Electronics.	Ask students to investigate several occupations in any of the following areas related to Electricity/Electronics: 1) Engineering and design, 2) Technical work, 3) Service Trades, 4) Broadcasting, 5) Construction, 6) Maintenance, 7) Sales, 8) Production and assembly.	
B. SKILLS & APTITUDES		
The student should be able to:		
1. Identify skills required for a particular occupation/career.	Have students select an occupation to research. Encourage them to discover the skills required for that job.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Outline the training required.	Once skills have been identified for a particular job, ask students to investigate and discuss the training required. Also, identify where appropriate training can be obtained.	
3. Discuss attitudes for achievement.	Ask students to develop a list of attitudes which might affect achievement in a career. Encourage discussion of both positive and negative attitudes.	
4. Predict the impact of technology on the career/occupation.	Have students speculate as to the types of jobs which will become obsolete or more abundant due to changes in technology.	
C. JOB SEARCH TECHNIQUES		
The student should be able to:		
1. Identify major job advertisement sources.	Discuss sources of job listings to which students may have access.	

OBJECTIVES	TEACHERS' NOTES AND SUGGESTED ACTIVITIES	SUGGESTED MATERIALS
2. Interpret written job descriptions.	Develop criteria for gleaning important information from job descriptions.	
3. Demonstrate skill in writing resumes and preparing for job interviews.	Ask students to prepare a resume.	

bibliography

APPENDIX

ELECTRICITY-ELECTRONICS BIBLIOGRAPHY

RECOMMENDED MATERIAL

Recommended Student Texts:

101 Braby ELECTRONICS: A PRACTICAL APPROACH (Metric), John Wiley, 1983
-- ELECTRICAL WIRING (Plus Cdn supplement), AAVIM, 1981

201 Gerrish & Drugger TRANSISTOR ELECTRONICS, Goodheart-Wilcox, 1979

301 Tokhelm DIGITAL ELECTRONICS, (2nd ed.), McGraw-Hill, 1984
Grob TELEVISION AND VIDEO SYSTEMS (5th ed.), McGraw-Hill, 1984

Recommended Teacher Reference:

101 Heath CONCEPTS OF ELECTRONICS, Heath, 1986
Matt ELECTRICITY AND BASIC ELECTRONICS, Goodheart-Wilcox, 1982

201 Heathkit SEMICONDUCTOR DEVICES, Heath, 1986
Malvino ELECTRONIC PRINCIPLES, McGraw-Hill, 1984
Schuler ELECTRONICS PRINCIPLES AND APPLICATIONS, McGraw-Hill, 1984

301 Jim Fry DIGITAL TECHNIQUES, Heath, 1986
Heathkit MICROPROCESSORS, Heath, 1986
Malvino DIGITAL COMPUTER ELECTRONICS, McGraw-Hill, 1983
Nashelsky INTRODUCTION TO DIGITAL TECHNOLOGY, John Wiley, 1983

ELECTRICITY-ELECTRONICS 101

	Recommended		Teacher Reference		
MODULES	ELECTRONICS: A PRACTICAL APPROACH	ELECTRICAL WIRING	ELECTRICITY & BASIC ELECTRONICS	CONCEPTS OF ELECTRONICS	ELECTRICITY 1 - 7
- Student Orientation & Safety					
A. Student Orientation			Chapter 2		
B. Safety	Chapter 1,5				
- Tools & Soldering Techniques					
A. Tools	Chapter 1,2,5				
B. Solder & Soldering Tools	Chapter 9				
- D. C. Theory					
A. Current	Chapter 12		Unit 1		
B. Voltage	Chapter 12				
C. Resistance	Chapter 12				
D. Ohms & Watts Law	Chapter 16				
E. Series & Parallel Circuits	Chapter 14				
F. Measuring El. Quantities	Chapter				
G. Magnetism	Chapter				
H. Motors & Generators	--				
- Passive Components					
A. Component Identification	Chapter 7		Unit 1		
B. Resistors & Color Code	Chapter 16				
C. Capacitors	Chapter 17				
D. Switches	Chapter 14				
E. Bulbs	---				
F. Batteries & Cells	Chapter 13				
G. Fuses & Circuit Breakers	Chapter 14				

	Recommended		Teacher Reference		
MODULES	ELECTRONICS: A PRACTICAL APPROACH	ELECTRICAL WIRING	ELECTRICITY & BASIC ELECTRONICS	CONCEPTS OF ELECTRONICS	ELECTRICITY 1 - 7
- A.C. Theory					
A. A.C. vs D.C.	---			Unit 2	
B. Generating A.C.	Chapter 14			Unit 2	
C. Measuring A.C.	Chapter 11			Unit 2	
D. Inductors in A.C. Circuits	Chapter 18			Unit 2	
E. Transformers	Chapter 18			Unit 2	
F. Capacitors in A.C. Circuits	Chapter 17			Unit 2	
- Active Components					
A. Semiconductor Awareness	Chapter 7,19			Unit 3	
B. Semiconductor Current Flow	Chapter 19			Unit 3	
C. Testing Semi Conductors	Chapter 19			--	
- Power Supplies					
A. What is a Power Supply?	---			Unit 4	
B. Rectification	---			Unit 4	
C. Filter Circuits	---			Unit 4	
D. Voltage Regulator Circuits	---			Unit 4	
E. Designing & Testing Paper Supplies	---			Unit 4	
- Audio Circuits					
A. Sound	---			Unit 4	
B. Audio Frequency	---			Unit 4	
C. Audio Systems	---			--	
D. Input & Output Devices	Chapter 13			--	
E. Speakers	Chapter 13			--	
F. Headphones	---			--	
G. Power & Voltage Amplifers	---			Unit 4	
H. Basic Amplifier Circuits	---			Unit 4	
I. Amplifier Controls	---			--	
J. Service Techniques	---			--	

	Recommended		Teacher Reference		
MODULES	ELECTRONICS: A PRACTICAL APPROACH	ELECTRICAL WIRING	ELECTRICITY & BASIC ELECTRONICS	CONCEPTS OF ELECTRONICS	ELECTRICITY 1 - 7
- Residental Wiring					
A. Power Distribution	---	Chapter 1-7			
B. Safety	---	Chapter 1-7			
C. Tools & Equipment	---	Chapter 1-7			
D. Conductors & Insultors	---	Chapter 1-7			
E. Blueprint Symbols	---	Chapter 1-7			
F. Boxes & Related Hardware	---	Chapter 1-7			
G. Devices	---	Chapter 1-7			
H. Connectors & Splicing Devices	---	Chapter 1-7			
I. Basic Circuits	---	Chapter 1-7			
J. Small & Major Appliance Circuits	---	Chapter 1-7			
- Career Explorations					
A. Career Classification	Chapter 1				
B. Skills & Aptitudes	Chapter 1				
C. Job Search Technique	---				
- Printed Circuits					
A. P.C.B. Identification	Chapter 10				
B. Advantage of P.C.	Chapter 10				
C. P.C.B. Construction	Chapter 10				
D. Soldering P.C.B.	Chapter 10				

ELECTRICITY-ELECTRONICS 201

Recommended		Teacher Reference			
MODULES	TRANSISTOR ELECTRONICS	ELECTRONICS PRINCIPLES & APPLICATIONS	SEMI CONDUCTOR DEVICES	BASIC ELECTRONICS	ELECTRONICS PRINCIPLES
- Student Orientation & Study	---				
- Components					
A. Pure Semiconductors	Chapter 3		Unit 1		
B. Doped Semiconductors	Chapter 12		Unit 1		
C. Diode Construction	Chapter 12		Unit 2		
D. Diode Characteristics	Chapter 12		Unit 2		
E. Zener Diodes	Chapter 12		Unit 3		
F. Transistors	Chapter 13		Unit 5,6		
G. Field Effect Transistors	Chapter 14		Unit 7		
H. Silicon Controlled Rectifiers	Chapter 12		Unit 8		
I. Unijunction Transistors	Chapter 14		Unit 8		
J. DIAC	---	Unit 8	Unit 8		
K. TRIAC	Chapter 12		Unit 8		
L. Integrated Circuits	Chapter 19		Unit 9		
- Amplifiers					
A. Principles	Chapter 14				
B. Amplifiers Circuit Coupling	Chapter 15				
C. Amplifier Performance Characteristics	---				
D. Feedback Amplifiers	---	Chapter 6,16		Chapter 5,6 7,8,9,10	
E. Power Amplifiers Fundamental	Chapter 15				
F. Transformerless Power Amps	Chapter 15				
G. Troubleshooting	---	Chapter 10			

Recommended		Teacher Reference			
MODULES	TRANSISTOR ELECTRONICS	ELECTRONICS PRINCIPLES & APPLICATIONS	SEMI CONDUCTOR DEVICES	BASIC ELECTRONICS	ELECTRONICS PRINCIPLES
- Electronic Circuits					
A. Amplifier Circuits	Chapter 14, 15				
B. Power Supply Circuits	Chapter 12	Chapter 4			
C. Oscillators	Chapter 16	Chapter 11			
D. Modulation/Demodulation	Chapter 17	Chapter 12	Chapter 27	Chap. 27,28	
E. Tuned/Resonent Circuits	---	---			
- Radio					
A. History	---				
B. Radio Frequency Spectrum	Chapter 17				
C. A.M. Radio System	Chapter 17				
D. Superhetrodyne Circuits	Chapter 17				
E. A.M. Radio Troubleshooting	---	Chapter 12			
F. F.M. Radio Systems	Chapter 17				
G. F.M. Stereo	---				
H. Future Trends in Radio	---				
- Opto Electronics					
A. Light Sources & Displays	---		Unit 10		Chapter 4
B. Light Reactive Devices	---		Unit 10		
C. Photo Voltaics	---		Unit 10		
D. Fiber Optics	---		--		
- Residential Wiring	(See 101 Residential Wiring)				
A. Introduction					
B. Tools & Equipment	---				
C. Blueprint Reading	---				
D. Service Entrance	---				
E. Devices	---				
F. Conductors/Splicing Devices	---				
G. Heating Systems	---				
H. Estimating Costs	---				
I. Motors	---				

Recommended		Teacher Reference			
MODULES	TRANSISTOR ELECTRONICS	ELECTRONICS PRINCIPLES & APPLICATIONS	SEMI CONDUCTOR DEVICES	BASIC ELECTRONICS	ELECTRONICS PRINCIPLES
- Printed Circuits					
A. Types of P.C.B. Materials	Appendix 5				
B. Design and Manufacturing Process	Chapter 19				
C. P.C.B. Etching & Assembly	Appendix 5				
- Careers					
A. Career Classification	Chapter 21				
B. Skills & Aptitudes	Chapter 21				
C. Job Search Techniques	Chapter 21				

ELECTRICITY-ELECTRONICS 301

	Recommended		Teacher Reference			
MODULES	DIGITAL ELECTRONICS	TELEVISION & VIDEO SYSTEMS	DIGITAL COMPUTER ELECTRONICS	INTRO TO DIGITAL TECHNOLOGY	DIGITAL TECHNIQUES	INTRO TO MICRO PROCESSORS
- Student Orientation & Safety	Preface ix	---				
- Components						
A. Integrated Circuits	---	---	Chapter 2,3,4,7			
B. Crystals	---	---				
- Electronic Circuits						
A. IC's OP Amps	---	---	Chapter 16			
B. Pulse Circuits	---	---		Chapter 7		
- Elect. Communication Systems						
A. Introduction	---	---				
B. Information Encoding	Chapter 5	---				
C. Information Transmission	---	---				
D. Decoding Demodulation	Chapter 12	Chapter 12				
E. Output Display	Chapter 5	Chapter 4				
F. Storage of Information	Chapter 10	---				
- Television						
A. Introduction	---	Chapter 1,2				
B. Applications of TV	---	Chapter 10				
C. TV Picture	---	Chapter 2				
D. TV Cameras	---	Chapter 3				
E. Picture Tubes	---	Chapter 4				
F. Composite Video Sequal	---	Chapter 7				
G. TV Circuits	---	Chapter 12				
H. Cable TV	---	Chapter 15				
I. TV World Systems	---	Appendix D				

	Recommended		Teacher Reference			
MODULES	DIGITAL ELECTRONICS	TELEVISION & VIDEO SYSTEMS	DIGITAL COMPUTER ELECTRONICS	INTRO TO DIGITAL TECHNOLOGY	DIGITAL TECHNIQUES	INTRO TO MICRO PROCESSORS
- Digital Concepts & Microprocessors						
A. Intro to Digital Technology	Chapter 1	---			Unit 1	--
B. Number Systems	Chapter 1	---			Unit 1	Unit 1
C. Logic Elements (Gates)	Chapter 3,4	---			Unit 3	--
D. Memory Circuits	Chapter 5,6,7	---			Unit 7	--
E. Computer Systems	Chapter 10,11	---			Unit 10	Unit 2
F. Microprocessors	Chapter 11	---			Unit 10	Unit 2
G. Programming	---	---			---	Unit 4
H. Troubleshooting Digital Circuits	Chapter 3-5, 7-9	---			---	--
- Fiber Optics						
A. Optical Energy	---	---				
B. Light Sources	---	---				
C. Optical Fibers	---	Chapter 15				
D. Receivers	---	---				
E. Fiber Optic Systems	---	---				
- Residental Wiring						
A. Power Distribution	---(See 101	---				
B. Safety	---Residential	---				
C. Tools & Equipment	---Wiring)	---				
D. Conductors & Insultors	---	---				
E. Blueprint Symbols	---	---				
F. Boxes & Related Hardware	---	---				
G. Devices	---	---				
H. Connectors & Splicing Devices	---	---				
I. Basic Circuits	---	---				
J. Small & Major Appliance Circuits	---	---				

	Recommended		Teacher Reference			
MODULES	DIGITAL ELECTRONICS	TELEVISION & VIDEO SYSTEMS	DIGITAL COMPUTER ELECTRONICS	INTRO TO DIAGRAM TECHNOLOGY	DIGITAL TECHNIQUES	INTRO TO MICRO PROCESSORS
- Career Explorations						
A. Career Classification	---	---				
B. Skills & Aptitudes	---	---			Unit 1	
C. Job Search Technique	---	---			Unit 1	

REFERENCE MATERIAL

A Practical Introduction to Light Wave Communication, Forest M. Mims III, 1982 (HWS)

Basic Electronics: A Text-Lab Manual, 5th Edition, Zbar/Malvino, 1983 (MH)

Concepts of Electronics, Heath Editors, 1986 (HCE)

Commodore 64 Interfacing Bluebook, V.J. Georgiou, 1984 (MP)

Electronic Circuits, Heath Editors, 1984 (HCE)

Electronic Principles & Applications, Schuler, 1984 (MH)

Electronics for Hobbiests, Heath Editors, 1986 (HCE)

Fiber Optics, Heath Editors, 1983 (HCE)

Fiber Optics and Laser Handbook, Safford, 1984 (TB)

Getting Started in Electronics, Mims, 1983 (RS)

Hardware Interfacing with the TRS-80, John E. Uffenbeck, 1983 (PH)

Heath's Robot "Hero" 68 Experiments: Fundamentals and Applications, Howard Boyet, 1983 (MT)

Hero 1: Advanced Programming & Interfacing, Mark J. Robillard, 1983 (HWS)

Interface Projects for the TRS-80 (Mod III), Richard C. Hallgren, 1982 (PH)

Mino/Micro Soldering and Wire Wrapping, Rosenthal, 1978 (HB)

Optoelectronics, Heath Editors, 1985 (HCE)

Robotics Age: In the Beginning, Hayden, 1983 (MT)

Robotics: An Introduction, Douglas R. Malcolm, Jr., 1985 (BP)

Robotics and Industrial Electronics, Heath Editors, 1983 (HCE)

Robotics Revolution, Simon & Schuster, 1983 (MT)

SemiConductor Devices, Heath Editors, 1986 (HCE)

Solar Cells and Photo Cells, Rufus Turner, 1980 (HWS)

Television Simplified, Kiver/Kaufman, 1973 (DP)

The Sound & The Fury, An Anecdotal History of Canadian Broadcasting, Troyer, 1982 (PL)

TRS-80 Interfacing Book 1, Jonathan A. Titus, 1979 (HWS)

TRS-80 Interfacing Book 2, Jonathan A. Titus, Christopher A. Titus, & David G. Larsen, 1980 (HWS)

Understanding Communication Systems, Cannon/Luecke, 1984 (TI)

Understanding Data Communications, Friend, et al, 1984 (TI)

Understanding Oprtronics, Masten/Masten, 1981 (TI)

Understanding Telephone Electronics, Fike/Friend, 1984 (TI)

Working Robots, Hayden, 1983 (MT)

Z-80 Microprocessor Programming and Interfacing, Book 1, Elizabeth A. Nichols, Joseph C. Nichols, Peter R. Rony, 1979 (HWS)

Z-80 Microprocessor Programming and Interfacing, Book 2, Elizabeth A. Nichols, Joseph C. Nichols, Peter R. Rony, 1979 (HWS)

MAGAZINES, JOURNALS, PERIODICALS

Charts, posters, brochures,...
available from: Manitoba Hydro
820 Taylor Avenue
Winnipeg, MB R3M 3T1

Electronics Today International
available from: Electronics Today International
Unit 6, 25 Overlea Boulevard
Toronto, ON M4H 1B1

Hands On Electronics
Radio Electronics
available from: Gernsback Publications Inc.
200 Park Avenue South
New York, NY 1003 USA

High Technology
available from: High Technology
P.O. Box 2808
Boulder, CO 80321 USA

Industrial Education
available from: Cummins Publishing Company
1495 Maple Way
Troy, MI 48084 USA

School Shop
available from: Prakken Publications Inc.
416 Longshore Drive
P.O. Box 8623
Ann Arbor, MI 48107 USA

Science Dimension
available from: National Research Council
Ottawa, ON M1A 0R6

The Technology Teacher
available from: International Technology
Education Association
1914 Association Drive
Reston, VA 22091 USA

VISUAL/AUDIO-VISUAL

Kits

832	Basic DC Electricity for Heating, Venting and Air Conditioning (MEL)
833	Basic AC Electricity for Heating, Venting and Air Conditioning (Part 1) (MEL)
834	Basic AC Electricity for Heating, Venting and Air Conditioning (Part 2) (MEL)
K 621.381 D53	Digital Electronics Explained (MEL)
K 621.31924 E44	Electrical Housewiring Explained (MEL)
	Link II (MFOL02), 1983 (HFOP)
K 621.3192 R48 Pt.1, Pt. 2	Residential Electrical Wiring (MEL)
K 375	The Electrician (MEL)

16mm Film

The following films are available from the Manitoba Education Library. (MEL)

		Grade
2759	AC Parallel Circuits (Electric circuits; Electric currents)	7 - 12
2758	AC Series Circuits (Electric circuits; Electric currents)	7 - 12
4083	And What of the Future? (Questions what the effects of microelectronics will be on jobs & the way people live & work), 1980, 40 min., sound, color	7 - 12

2117	Basic DC Meter Movement (Electric meters)	10 - 12
0770	Basic Radio Circuitry, (Radio circuits)	10 - 12
1156	Basic Wiring (Electric wiring)	10 - 12
2750	Capacitance in AC Circuits (Electric capacity; Electric currents Alternating)	7 - 12
3764	Circuit Testing: Signal Generators (Oscillators, Electric; Signal generators; Frequency synthesizers; Frequency meters)	7 - 9
1866	Circuit Testing With Meters and Multimeters--Practical Application (Electric testing, Electric meters)	10 - 12
0955	Development of Communication: From Telegraph to TV (Telecommunication)	7 - 12
1750	Electrical Sources (Electricty)	4 - 12
3147	Electronics (Vacuum-tube circuits; Transistor circuits; electronics)	4 - 12
2557	Fundamentals of AC and DC Generation (Electric currents, Alternating; Electric currents, Direct)	4 - 12
1671	Inductance in AC Circuits (Electricity; Electric circuits- Alternating current; Inductance)	7 - 12
4074	Now The Chips Are Down (Examines the makings of silicon chips and how they are used. Changes that microprocessors will bring in the future. 1978, 50 min., sound, color)	10 - 12
0232	Pressure and Current (Electric circuits; Electric measurements; Electric meters)	10 - 12
3119	Principles of Television (Television - Receivers and reception)	10 - 12

2143	RCL (Electricity; Electric resistance; Electric currents; Impedance-Electricity)	10 - 12
4081	So What's It All About? (Microelectric revolution with the advent of the silicon chip--how it's made, how it works and application). 1980, 40 min., sound, color	7 - 12
2957	The Generator and the Motor (Electric motors; electromagnetic theory)	10 - 12
1607	The Principle of the Generator: Electro-Magnetic Induction (Electromagnetic theory)	7 - 12
1143	The Transistor (Transistors)	10 - 12
VR 331.702 R42	Climbing The Ladder (Job Search Series)	7 - 12
VR 331.702 R42	First Impressions (Job Search Series)	7 - 12
VR 331.702 R42	Getting Ready (Job Search Series)	7 - 12
VR 331.702 R42	The Interview (Job Search Series)	7 - 12
VR 331.702 R42	The Market (Job Search Series)	7 - 12
VR 331.702 R42	Your Calling Card (Job Search Series)	7 - 12

(BP) Breton Publishers
P.O. Box 446
North Scituate, MA 02060 USA

(DP) Delmar Publishers
2 Computer Drive W.
P.O. Box 15015
Albany, NY 12212 USA

(HB) Hayden Book Company, Inc.
50 Essex Street
Rochelle Park, NJ 07662 USA

(HCE) Heath Computers & Electronics Company
1315 Portage Avenue
Winnipeg, MB R3G 0V3

(HFOP) High Frequency & Optical Products Division
P.O. Box 20912
Phoenix, AZ 85036 USA

(HWS) Howard W. Sams & Co, Inc.
4300 West 66nd Street
Indianapolis, IN 46268 USA

(MEL) Manitoba Education Library
Main Floor
1181 Portage Avenue
Winnipeg, MB R3G 0T3

(MH) McGraw-Hill Ryerson Limited
330 Progress Avenue
Toronto, ON M1P 2Z5

(MT) Microprocessor Training Inc.
14 East 8th Street
New York, NY 10003 USA

(MP) Microsignal Press
P.O. Box 388
Goleta, CA 93116 USA

(PL) Personal Library Publishers
12 Queen Street East
Toronto, ON M5C 1R4

(PH) Prentice-Hall Canada Inc.
1870 Birchmount Road
Scarborough, ON M1P 2J7

(RS) Radio Shack
Tandy Electronics Limited
279 Bayview Drive
Barrie, ON L4M 4W5

(TB) TAB Books Inc.
Monterey Avenue
Blue Ridge Summit, PA 17214 USA

(TI) Texas Instruments
P.O. Box 3640, M/S 8218
Dallas, TX 75285 USA